I-5 FROM SR-55 TO SR-57 HOV IMPROVEMENT PROJECT PA/ED

Transportation Analysis Report
Draft Final

EA OC8900

Prepared For:

Caltrans

OCTA

AECOM

April 12, 2013

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EXECUTIVE SUMMARY

The Orange County Transportation Authority (OCTA), in cooperation with the California Department of Transportation (Caltrans) and the cities of Santa Ana, Orange, and Tustin, is proposing alternative improvement strategies to add capacity and improve operations along the four-mile section of the Interstate 5 (I-5) Freeway between the State Route 55 (SR-55) and State Route 57 (SR-57) Freeways. These strategies generally include the provision of a second high-occupancy vehicle (HOV) lane northbound and southbound along I-5 between SR-55 and SR-57 and associated ramp and arterial improvements needed to accommodate the right-of-way (ROW) for the HOV lanes. In addition, improvements to the First Street entrance ramps to I-5 southbound are proposed to improve operations in the general purpose lanes and the downstream weave to the SR-55 southbound off-ramp.

According to Caltrans' *Federal Determination Report: ILEV/Hybrids on HOV Facilities in California* as required by the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy of Users (SAFETEA-LU, 2009), the HOV lanes northbound and southbound along I-5 between the SR-55 and SR-57 are considered degraded facilities.[1] The project proposes to alleviate the degradation by means of eliminating choke points and increasing capacity, thereby improving the operations of the HOV facility. This analysis evaluates the degradation within the project limits and how the project features will improve such degradation.

Based on a review of existing and future conditions, there are currently substantial bottlenecks in the HOV lanes where the I-5 and SR-57 HOV lanes merge in the southbound direction and where the I-5 and SR-55 HOV lanes merge in the northbound direction. These bottlenecks result in congestion along the HOV lanes, leading to substantial delays to HOV users. The proposed HOV improvements would reduce delays at these locations.

Review of accident data indicates safety concerns at freeway mainline, HOV, and ramp locations. All portions of I-5 between SR-57 and SR-55 exhibit higher accident rates than the statewide average. The HOV on- and off-ramps at Main Street showed a significantly higher accident rate than the statewide average. Two project alternatives propose the removal of these ramps, which would improve safety.

In addition, southbound I-5 between the First Street on-ramp and the SR-55 southbound diverge is a source of delay throughout the day, with the weaving section over capacity and congestion for mainline and ramp users.

This traffic report includes analysis of the following improvement strategies:

[1] Degraded facilities are defined as facilities where vehicles fail to maintain a minimum average operating speed of 45 mph for HOV facility with speed limit of 50 mph or greater, 90 percent of the time over a consecutive 180-day period (6 months) during morning or evening weekday peak hour periods or both.

- **No Build Alternative**
- **HOV Lane Alternative 2A:** Addition of one continuous-access HOV lane in each direction along northbound and southbound I-5 between SR-55 and SR-57. Access to the HOV lane will be provided continuously throughout the project limits. A concrete barrier will be constructed to separate the new HOV lane from the existing HOV lane in some locations, with removal of the barrier where possible to allow for access between the two HOV lanes.
- **HOV Lane Alternative 2B:** Same as Alternative 2A, except that the direct I-5 HOV northbound entrance and southbound exit ramps at Main Street would be removed.
- **HOV Lane Alternative 5A:** Addition of one continuous-access HOV lane in each direction along northbound and southbound I-5 between SR-55 and SR-57. This alternative generally removes the existing concrete barriers located between the existing HOV lane and the general-purpose lanes, providing a continuous ingress/egress striping throughout the project limits, except at bridge columns.
- **HOV Lane Alternative 5B:** Same as Alternative 5A, except that the direct I-5 HOV northbound entrance and southbound exit ramps at Main Street would be removed.
- **Ramp Alternative A:** Removal of the existing I-5 southbound entrance ramp at First Street and construction of a replacement entrance ramp at Fourth Street. Ramp Alternative A would also remove the northbound I-5 “horseshoe” exit ramp to Mabury Street/First Street. With this alternative, the weaving distance between the replacement Fourth Street on-ramp to the SR-55 off-ramp will be increased from 1,555 feet to 2,605 feet.
- **Ramp Alternative B:** Removal of the existing I-5 southbound entrance ramp at First Street and construction of a new entrance loop ramp on the north side of First Street. To accommodate the relocated on-ramp, Ramp Alternative B would also include minor modifications to the configuration of First Street. With this alternative, the weaving distance between the replacement Fourth Street on-ramp to the SR-55 off-ramp will be increased from 1,555 feet to 2,295 feet.

Project conditions were assessed for the anticipated Opening Year (2018) and Future Year (2040), for daily, weekday AM peak hour, and weekday PM peak hour time periods.

For the purpose of this traffic report, the HOV Lane Alternatives and the Ramp Alternatives have been studied as two separate project elements. The HOV project begins over 0.5 miles north of the current First Street on-ramp to I-5 southbound. Additionally, the mainline and HOV lane volumes are not anticipated to change due to the Ramp Alternatives. Given the distance and nature of the HOV Lane Alternatives versus the Ramp Alternatives, no overlap of the traffic impacts was anticipated between the two projects. Consequently, these two different projects were evaluated and assessed independently.

This report includes an integrated analysis of the freeway system to document the effects of implementation of the alternatives under consideration. Analysis of facilities has been

conducted using tools consistent with Caltrans' Measures of Effectiveness (MOEs) and is sensitive and responsive to the effects of adjacent facilities (e.g., upstream geometric factors, operational characteristics, vehicular adjustments). Facilities that have been analyzed include freeway mainline segments, freeway HOV lanes, freeway ramps, freeway weaving sections, and ramp/arterial intersections. A summary of traffic operations for the various alternatives is provided in this section.

ES-1 HOV LANE ALTERNATIVES

The existing I-5 HOV lanes currently have two locations at which bottlenecks constrain the ability of vehicles to proceed through the HOV lanes. In the northbound direction, immediately north of the Grand Avenue HOV off-ramp, the HOV facility transitions from two lanes to one lane. In the southbound direction, at the SR-57 HOV on-ramp, the HOV facility also transitions from two lanes to one lane. The HOV Lane Alternatives would provide a second HOV lane in both the northbound and southbound directions along I-5 for the entire distance between SR-55 and SR-57 to remove the north and southbound constrained locations and to provide additional HOV lane capacity.

In general, the analysis conducted for the HOV Lane Alternatives was focused within the project limits, with additional freeway mainline and HOV lane analysis locations at the north end and south end of the segment.

Freeway Mainline Segments

Table ES-1 summarizes the number of freeway mainline segments out of the 12 analysis locations that would operate at LOS E/F under each HOV Lane alternative.

Table ES-1: Freeway Segments Operating at LOS E/F by HOV Lane Alternative

	No. of Locations	2018				
		No Build	Alt 2A	Alt 2B	Alt 5A	Alt 5B
AM Peak Hour	12	9	9	9	9	9
PM Peak Hour	12	10	10	10	10	10
		2040				
AM Peak Hour	12	12	12	12	12	12
PM Peak Hour	12	11	11	11	11	11

Source: AECOM 2012

As shown in Table ES-1, overall conditions along the I-5 Freeway within the study area would be similar between the various Opening Year (2018) and Future Year (2040) scenarios. However, conditions with Alternative 2B and 5B would be slightly worse than Alternative 2A and 5A, as the elimination of the I-5 direct HOV on- and off-ramps at Main Street would require high-occupancy vehicles (fewer than 300 vehicles per hour in the southbound direction and fewer than 500 vehicles per hour in the northbound direction) to use other nearby on- and off-ramps, thereby increasing volumes along the I-5 general-purpose lanes north of Main Street.

Freeway HOV Segments

Table ES-2 summarizes the number of HOV lane segments out of the 18 analysis locations that would operate at LOS E/F under each alternative.

Table ES-2: HOV Lane Segments Operating at LOS E/F by HOV Lane Alternative

	No. of Locations	2018				
		No Build	Alt 2A	Alt 2B	Alt 5A	Alt 5B
AM Peak Hour	18	2	1	1	1	1
PM Peak Hour	18	5	1	1	1	1
		2040				
AM Peak Hour	18	2	6	4	6	4
PM Peak Hour	18	5	6	6	6	6

Source: AECOM 2012

Under Opening Year (2018) No Build and Future Year (2040) No Build conditions, severe bottlenecks would occur at the north end of the southbound HOV lane (at the I-5/SR-57 merge) and the south end of the northbound HOV lane (at the I-5/SR-55 merge). These bottlenecks would result in substantial delays and cause excessive queuing in both directions. Due to these bottlenecks, downstream HOV lane volumes are restricted and thus the HOV lanes would operate under capacity.

The second HOV lane associated with the HOV Lane Alternatives would alleviate the bottlenecks, increasing the capacity of the HOV lanes and the throughput of HOV users. In addition, the provision of additional HOV capacity would result in an increased activity in the HOV lanes (with the project, corridor HOV volumes would increase by 9 percent in 2018 and 33 percent in 2040 with Alternatives 2A/5A, and would increase by 6 percent in 2018 and 30 percent in 2040 with Alternatives 2B/5B).

As shown in Table ES-2, the HOV Lane Alternatives would substantially improve conditions within the HOV lanes under Year 2018 conditions, as the additional HOV lane in each direction would be sufficient to accommodate the projected increase in demand. However, by Year 2040, the anticipated demand for the HOV lanes would overwhelm the second HOV lane, resulting in over-capacity conditions and new congested locations.

Note that the HOV lane conditions with Alternatives 2B and 5B would operate slightly better than with Alternatives 2A and 5A, as the elimination of the I-5 direct HOV on- and off-ramp at Main Street would cause vehicles to leave the HOV lane and reroute to nearby general-purpose lane on- and off-ramps. At this location, it was estimated that in Year 2018, the elimination of the southbound off-ramp would affect 180 vehicles in the weekday AM peak hour and 80 vehicles in the weekday PM peak hour; the elimination of the northbound on-ramp would affect 65 vehicles in the weekday AM peak hour and 407 vehicles in the weekday PM peak hour. In Year 2040, it was estimated that the elimination of the southbound off-ramp would affect 290 vehicles in the weekday AM peak hour and 135 vehicles in the weekday PM peak hour; the elimination of the northbound on-ramp would affect 105 vehicles in the weekday AM peak hour and 485 vehicles in the weekday PM peak hour. Eliminating the Main Street direct HOV ramps would affect I-5 HOV users previously accessing I-5 at this location, but would not cause drivers to shift from HOV to single-occupant vehicles (SOV), although it would alter how local I-5 HOV users access the HOV lanes.

Weaving Segments

Table ES-3 summarizes the number of weaving segments out of the one analysis location that would operate at LOS F under each HOV Lane Alternative.

Table ES-3: Weaving Segments Operating at LOS E/F by HOV Lane Alternative

	No. of Locations	2018				
		No Build	Alt 2A	Alt 2B	Alt 5A	Alt 5B
AM Peak Hour	1	1	1	1	1	1
PM Peak Hour	1	1	1	1	1	1
		2040				
AM Peak Hour	1	1	1	1	1	1
PM Peak Hour	1	1	1	1	1	1

Source: AECOM 2012

As shown in Table ES-3, the assessed weaving segment would operate at LOS F and would remain the same with all project alternatives when compared to the No Build Alternatives.

Intersection Operations

Freeway ramp intersections with local streets were included within the study area to address the effects on freeway access, intersection level of service (LOS), and ramp queuing. In addition, the study area includes nine local intersections to identify any diversion of traffic flow and the changes to conditions on local arterial traffic operations. Table ES-4 provides a summary of the number of intersections, out of the nine analysis locations, that would operate at LOS E/F in either the weekday AM or PM peak hour for each alternative. It should be noted that since the general configuration of the I-5 Freeway and the HOV lanes would be the same between HOV Lane Alternative 2 and HOV Lane Alternative 5, the resulting intersection operating conditions would also be the same. It should also be noted that for each affected local intersection, minor modifications to signal timing (no geometric changes) were applied, where applicable, to account for additional vehicles that were redistributed as part of the alternatives.

Table ES-4: Intersections Operating at LOS E/F by HOV Lane Alternative

	No. of Locations	No Build	Alt 2A	Alt 2B	Alt 5A	Alt 5B
		2018				
AM Peak Hour	9	0	0	0	0	0
PM Peak Hour	9	0	0	0	0	0
		2040				
AM Peak Hour	9	0	0	0	0	0
PM Peak Hour	9	0	0	0	0	

Source: AECOM 2012

As shown in Table ES-4, all nine study intersections would operate acceptably (LOS D or better) under all alternatives and during both peak hours in 2018 and 2040.

ES-2 RAMP ALTERNATIVES

In addition to the HOV bottleneck areas studied as part of the HOV Lane Alternative analysis, the I-5/SR-55 interchange area experiences traffic congestion during peak travel periods due in part to the close proximity of the southbound First Street on-ramp to the SR-55 interchange. Thus, the Ramp Alternatives analysis evaluated the effect on traffic congestion of modifying or relocating the First Street southbound on-ramp. Both Ramp

Alternatives would increase the weaving distance between the First Street on-ramp and the SR-55 interchange, alleviating congestion associated with this weaving section. Since the Ramp Alternatives designs would alter traffic circulation patterns on the local streets, a local intersection analysis was also included to capture these effects.

Intersection Operations

Freeway ramp intersections with local streets were included within the study area to address the effects on freeway access, intersection level of service (LOS), and ramp queuing. In addition, the study area includes 22 existing and future local intersections to identify any diversion of traffic flow and the resulting benefits/impacts on local arterial traffic operations. Table ES-5 provides a summary of the number of intersections out of the 22 analysis locations operating at LOS E/F in either the AM or PM peak hour for each alternative.

Table ES-5: Intersections Operating at LOS E/F by Ramp Alternative

	No. of Locations	No Build	Ramp A	Ramp B
		2018		
AM Peak Hour	22	2	2	2
PM Peak Hour	22	2	2	2
		2040		
AM Peak Hour	22	2	2	2
PM Peak Hour	22	2	2	2

Source: AECOM 2012

As shown in Table ES-5, two of the 22 study intersections would operate at LOS E/F under all alternatives and during both peak hours; implementation of the Ramp Alternatives would not cause additional intersections to worsen to unacceptable conditions. Although Ramp Alternative B would require modifications to the configuration on First Street, it would not result in additional impacts to local intersections.

Weaving Segments

Table ES-6 summarizes the number of weaving segments out of the one analysis location that would operate at LOS F under each ramp alternative.

Table ES-6: Weaving Segments Operating at LOS F by Ramp Alternative

	No. of Locations	No Build	Ramp A	Ramp B
		2018		
AM Peak	1	1	1	1
PM Peak	1	1	1	1
		2040		
AM Peak	1	1	1	1
PM Peak	1	1	1	1

Source: AECOM 2012

As shown in Table ES-6, the one weaving segment would operate at LOS F and would remain the same with all project alternatives when compared to the No Build Alternative. However, the volume-to-capacity (V/C) ratio of the weaving segment would decrease with the Ramp Alternatives, illustrating that the two Ramp Alternatives would help to alleviate congestion in the weaving segment. Although the decrease in V/C would be relatively minimal (0.01) during both the weekday AM and PM peak hours, even small increases in

capacity can result in improved operations by reducing density and increasing speeds. In addition, both Ramp Alternatives would increase the segment weaving length to exceed Caltrans minimum weaving standards with the weave length for Ramp Alternative A proposed to be 2,605 feet and the weave length for Ramp Alternative B is proposed to be 2,295 feet.

ES-3 CONCLUSIONS

Overall, implementation of one of the HOV Lane Alternatives would result in the elimination of critical bottlenecks on the HOV network, thereby increasing HOV activity and facilitating HOV usage (estimated to be up to a 9 percent increase by Year 2018 and up to a 33 percent increase by Year 2040). Although the additional HOV lane in each direction would accommodate the anticipated demand in Year 2018, by Year 2040 the demand for the HOV facilities would be higher than the provided capacity, resulting in new congested locations.

Both Ramp Alternatives would improve the weave density with Ramp Alternative A performing slightly better due to the longer weaving distance available with this alternative. However, the magnitude of improvements is limited due to the overall over capacity conditions on the I-5 mainline.

Reconfiguring and relocating the First Street southbound on-ramp (and the associated changes to the Fourth Street northbound off-ramp) would cause changes in the local circulation patterns, both on the mainline and surface streets. However, these would not be substantial enough to affect roadway and freeway conditions. Evaluation of queuing at ramp locations also identified that adequate storage would be provided to accommodate anticipated queues and thus not spillback to the mainline.

Review of accident data indicates safety concerns at freeway mainline, HOV, and ramp locations. All portions of the I-5 between the SR-57 and SR-55 exhibit a higher accident rate than the statewide average. The HOV ramps at Main Street showed a significantly higher accident rate than the statewide average. Two of the HOV Lane Alternatives propose the removal of these ramps, which would improve safety.

1.0 INTRODUCTION

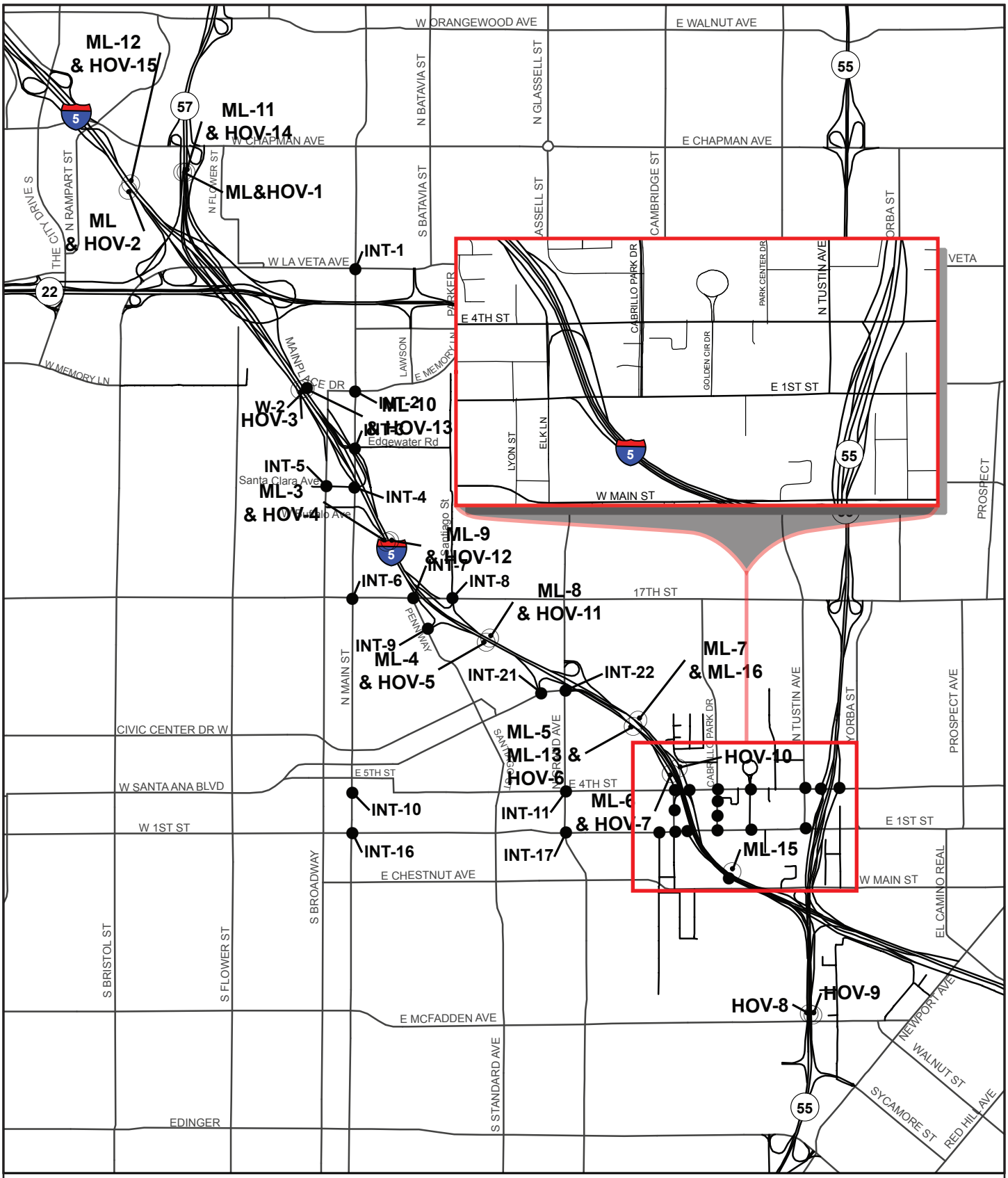
This Transportation Analysis Report (TAR) has been prepared as a technical study for the Project Approval/Environmental Document (PA/ED) phase of the I-5 From SR-55 to SR-57 HOV Improvement Project. The purpose of this TAR is to present the results of a comprehensive and integrated analysis of the potential future operations of the four-mile section of the I-5 Freeway from the SR-55 Freeway to the SR-57 Freeway, including freeway facilities, ramps and local intersections. Figure 1 shows the project location and vicinity map. Figure 2 shows the existing freeway lane geometry.

The purpose of this analysis is to inform the design of the freeway project based on the Caltrans Measures of Effectiveness (MOE) and levels of service (LOS). Additionally, this report provides the technical foundation for the preparation of subsequent environmental documentation under the California Environmental Quality Act (CEQA) and the National Environmental Policy Act (NEPA).

The study includes the evaluation of Existing, Opening Year (2018), and Future Year (2040) conditions under a No Build scenario and with two sets of project alternatives: HOV Lane Alternatives and Ramp Alternatives. Conditions are analyzed in this report for typical weekday AM and PM peak hours. This analysis examines traffic volumes and LOS in the vicinity of the project under the following scenarios:

- Existing Conditions
- Opening Year (2018) No Build Conditions
- Opening Year (2018) HOV Lane Alternative 2A Conditions
- Opening Year (2018) HOV Lane Alternative 2B Conditions
- Opening Year (2018) HOV Lane Alternative 5A Conditions
- Opening Year (2018) HOV Lane Alternative 5B Conditions
- Opening Year (2018) Ramp Alternative A Conditions
- Opening Year (2018) Ramp Alternative B Conditions
- Future Year (2040) No Build Conditions
- Future Year (2040) HOV Lane Alternative 2A Conditions
- Future Year (2040) HOV Lane Alternative 2B Conditions
- Future Year (2040) HOV Lane Alternative 5A Conditions
- Future Year (2040) HOV Lane Alternative 5B Conditions
- Future Year (2040) Ramp Alternative A Conditions
- Future Year (2040) Ramp Alternative B Conditions

This report includes an integrated analysis of the freeway system to document the effects of implementation of the alternatives under consideration. Traffic volume forecasts (described in later sections) have been prepared with upstream/downstream freeway mainline and ramp terminus conservation of flow as a priority.



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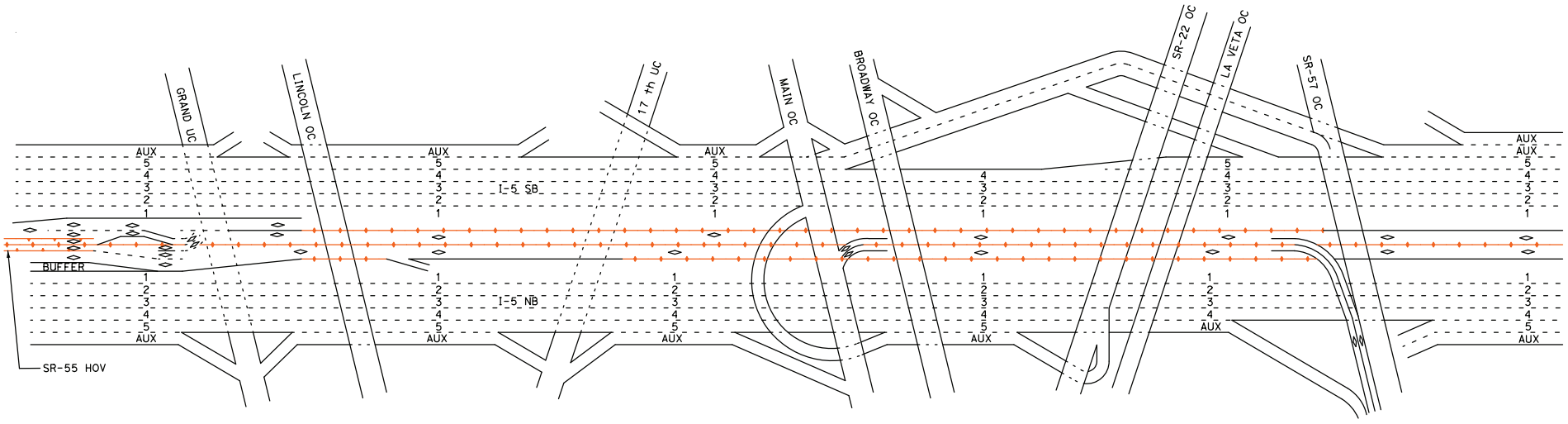
I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED
Figure 1 - Project Location and Vicinity Map



EXISTING

LEGEND

CONCRETE BARRIER

RETAINING WALL

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I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED

Figure 2 - Existing Freeway Lane Geometry

Analysis of facilities has been conducted using tools consistent with Caltrans MOEs and is sensitive and responsive to the effects of adjacent facilities (e.g., upstream geometric factors, operational characteristics, vehicular adjustments). Facilities that have been analyzed include:

- Freeway mainline segments
- Freeway HOV lanes
- Freeway ramps
- Freeway weaving sections
- Ramp/arterial intersections

This TAR has been prepared as a stand-alone document in support of the overall I-5 HOV Improvement Project (SR-55 to SR-57) development process. The TAR is intended to confirm the overall freeway system design efficacy. Analyses have been conducted to determine whether the proposed design results in improved facility operations when compared to Existing, Opening Year (2018), and Future Year (2040) No Build Alternative conditions.

For the TAR, the HOV Lane Alternatives and the Ramp Alternatives have been studied as two separate project elements. With the HOV Lane Alternatives, the second northbound and southbound HOV lanes would be located over 0.5 miles north of the current First Street entrance ramp to I-5 southbound, and there are projected to be no changes to the mainline or HOV lane volumes in and around the First Street on-ramp area. Similarly, the Ramp Alternatives are not anticipated to affect mainline or ramp volumes to the north of Fourth Street. Since there would no overlap of traffic impacts or changes to traffic volumes that could affect conditions, this separation would allow the two project elements to be evaluated and assessed independently

1.1 PROJECT DESCRIPTION

OCTA, in cooperation with Caltrans and the cities of Santa Ana, Orange, and Tustin is proposing alternative improvement strategies to add capacity and improve operations along the four-mile section of the I-5 Freeway between the SR-55 and SR-57 Freeways. These strategies generally include the provision of a second high-occupancy vehicle (HOV) lane northbound and southbound along I-5 between SR-55 and SR-57 and associated ramp and arterial improvements needed to accommodate the right-of-way (ROW) for the HOV lanes. In addition, improvements to the First Street entrance ramp to I-5 southbound are proposed to improve operations in the general purpose lanes and the downstream weave to the SR-55 southbound off-ramp.

The following section presents a detailed description of all the alternatives analyzed in this report for both Opening Year (2018) and Future Year (2040) conditions.

1.1.1 NO BUILD ALTERNATIVE

The No Build Alternative includes no capital improvements to the I-5 corridor between SR-55 and SR-57. The No Build Alternative considers the I-5 Freeway and associated facilities in its existing geometrics and configuration, with the exception of proposed

projects that are under development or currently in construction. As no projects are currently proposed along this section of I-5 and the surrounding local street network, the No Build Alternative would have the same configuration as under Existing conditions (as shown on Figure 2). Note, however, that the Future Year (2040) No Build conditions include the proposed modifications to SR-55 to the south of I-5, which are currently undergoing environmental review.

1.1.2 HOV LANE ALTERNATIVE 2A

HOV Lane Alternative 2A provides an addition of one continuous access HOV lane in each direction along northbound and southbound I-5 between the SR-55 and SR-57 Freeways. Ingress/egress to the HOV lane will be provided continuously throughout the project limits. A concrete barrier will be constructed to separate the new HOV lane from the existing HOV lane, with openings at specific locations to allow vehicles to switch lanes. It is anticipated that access to the HOV lanes for Alternative 2A will be continuous, except where limited by striping or barriers. The design of Alternative 2A is illustrated in Figure 3.

1.1.3 HOV LANE ALTERNATIVE 2B

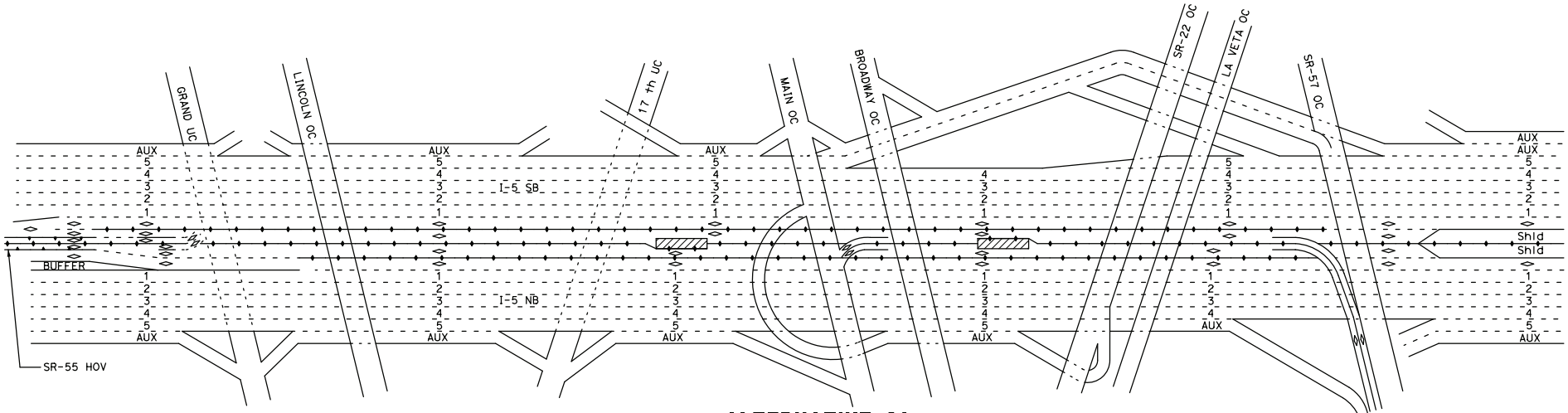
HOV Lane Alternative 2B will be the same as Alternative 2A, except that the I-5 HOV direct northbound entrance and southbound exit ramps at Main Street will be removed. Figure 3 shows HOV Lane Alternative 2B.

1.1.4 HOV LANE ALTERNATIVE 5A

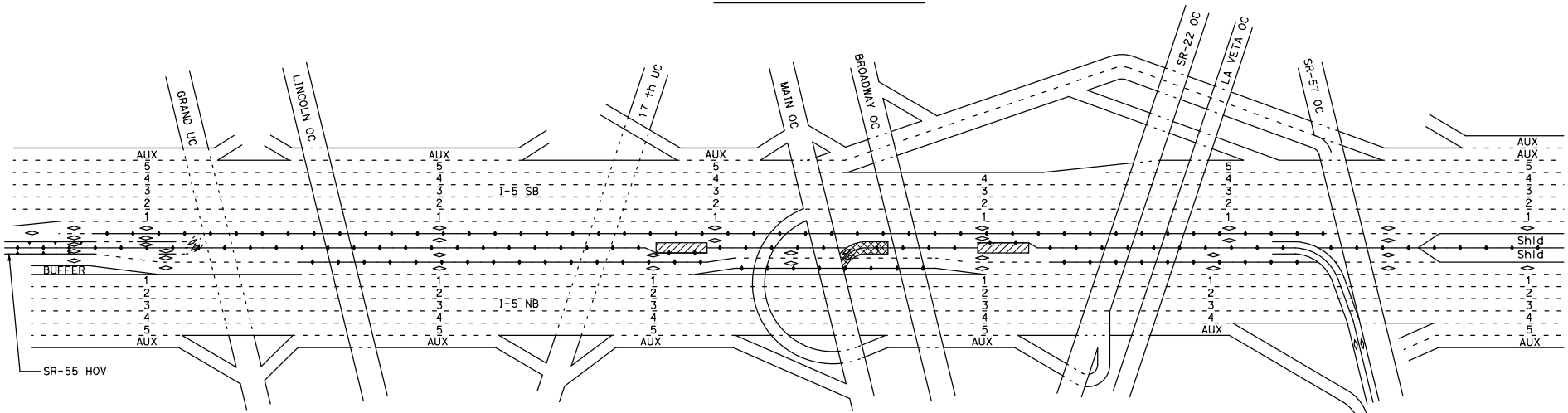
HOV Lane Alternative 5A provides an addition of one restricted access HOV lane in each direction along northbound and southbound I-5 between the SR-55 and SR-57 Freeways. This alternative will remove the existing concrete barriers located between the existing HOV lane and the general-purpose lanes providing a continuous ingress/egress striping throughout the project limits, except at bridge columns. It is anticipated that access to the HOV lanes for Alternative 5A will be continuous, except where limited by striping or barriers. The design of HOV Lane Alternative 5A is illustrated in Figure 4.

1.1.5 HOV LANE ALTERNATIVE 5B

HOV Lane Alternative 5B will be the same as HOV Lane Alternative 5A, except that the I-5 HOV northbound entrance and southbound exit ramps at Main Street will be removed. Figure 4 shows HOV Lane Alternative 5B.



ALTERNATIVE 2A



ALTERNATIVE 2B

LEGEND

- CHP ENFORCEMENT AREA
- DEMOLISH
- CONCRETE BARRIER
- RETAINING WALL

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Figure 3 - HOV Alternative 2A/2B Improvements

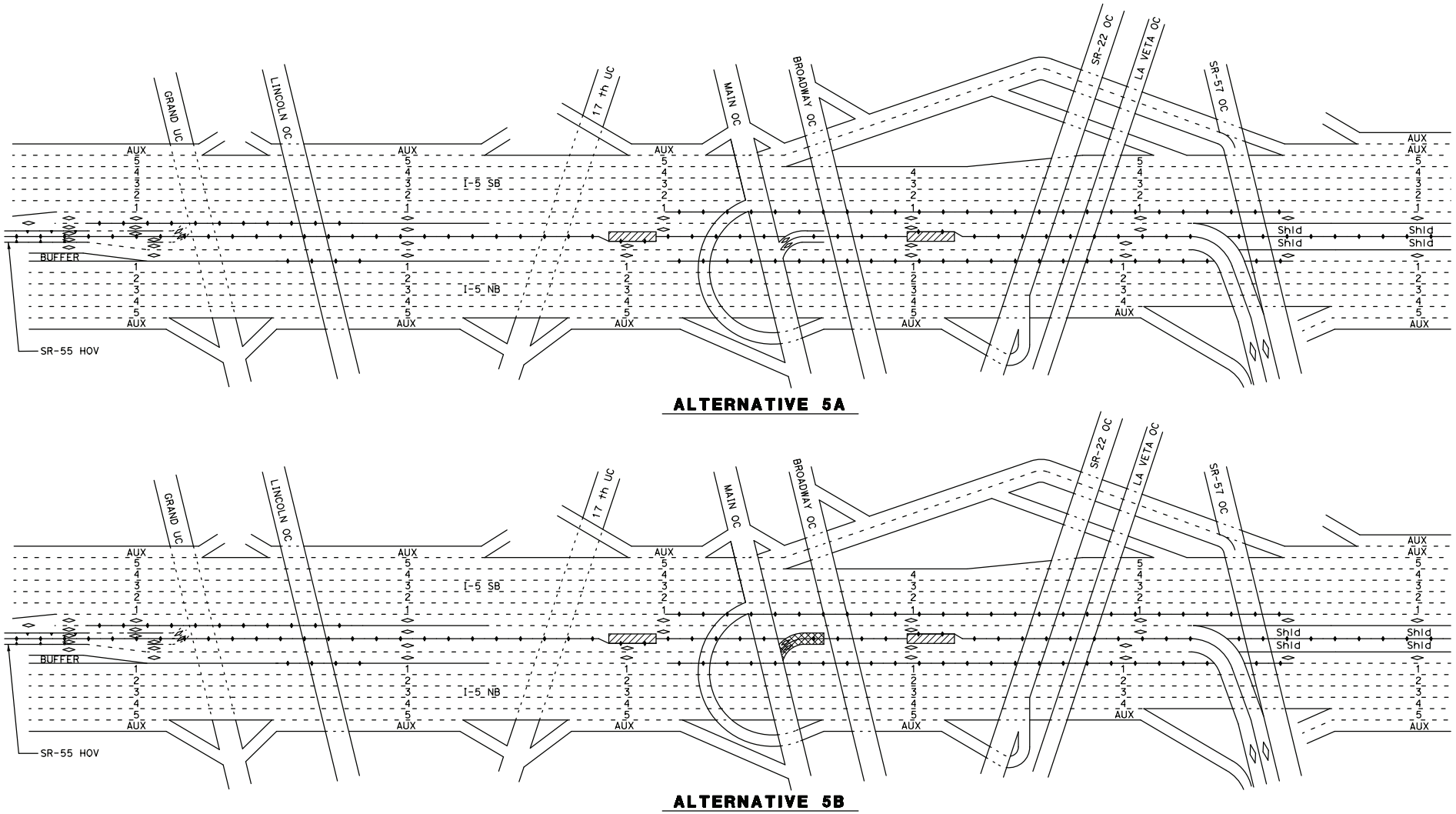

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Figure 4 - HOV Alternative 5A/5B Improvements

1.1.6 RAMP ALTERNATIVE A

This ramp alternative will remove the existing I-5 southbound entrance ramp at First Street and construct a relocated entrance ramp from Fourth Street. The proposed engineering features of Ramp Alternative A are as follows:

- Remove the existing First Street to southbound I-5 entrance ramp and construct a new entrance ramp at Fourth Street to create a full diamond interchange. Remove the traffic signal at First Street/I-5 southbound entrance ramp and restripe the entrance ramp to the I-5 mainline.

- Remove the northbound I-5 "horseshoe" exit ramp to Mabury Street/First Street, add a second left-turn lane on the northbound I-5 exit ramp to westbound Fourth Street and restripe portions of the northbound exit ramp at this location.

- Reconfigure Mabury Street into a two-way street from Palm Street to First Street and modify the Mabury Street/First Street intersection accordingly. Add a left-turn lane at eastbound First Street to northbound Mabury Street. Remove existing access to Mabury Street from Fourth Street.

- Restripe portions of First Street, Fourth Street, and Mabury Street to ensure operational continuity.

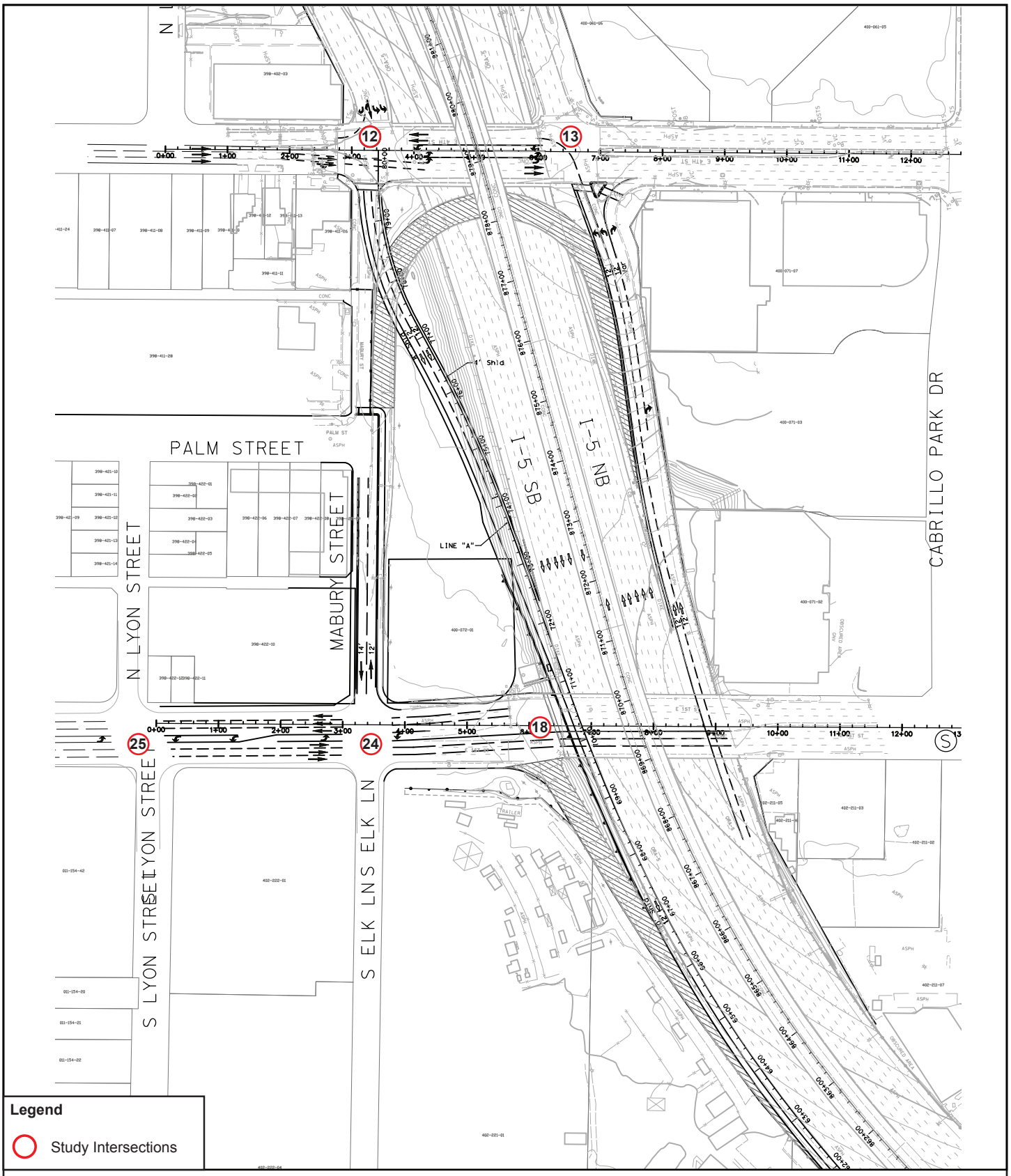
As a result of these changes, the weave distance (i.e., the distance between the end of the upstream ramp and the start of the downstream ramp) between the relocated Fourth Street ramp and the downstream SR-55 exit will be lengthened to 2,605 feet (an increase of 1,050 feet over the existing configuration). Ramp Alternative A improvements are illustrated in Figure 5.

1.1.7 RAMP ALTERNATIVE B

This alternative will remove the existing I-5 southbound entrance ramp at First Street and construct a reconfigured entrance loop ramp on the vacant parcel between First Street and Fourth Street and between Mabury Street and the southbound I-5 mainline within the City of Santa Ana and Caltrans right-of-way (ROW). The improvements as part of Ramp Alternative B are illustrated in Figure 6. The proposed engineering features of Ramp Alternative B are as follows:

- Remove First Street entrance ramp and construct the new entrance loop ramp within the vacant parcel between First Street, Fourth Street and southbound I-5 mainline. Remove traffic signal at First Street and southbound I-5 entrance ramp. Restripe entrance ramp to mainline.

- Modify northbound I-5 "horseshoe" exit ramp to Mabury Street/First Street to remove the 2nd ramp lane prior to the intersection with Mabury Street.



I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED
Figure 5 - Ramp Alternative A Improvements

- Reconfigure Mabury Street as a two way street and modify Mabury Street/First Street intersection accordingly. Add dual left turn lanes at eastbound First Street and an exclusive right turn lane for westbound First Street to northbound Mabury Street/southbound I-5 entrance ramp.

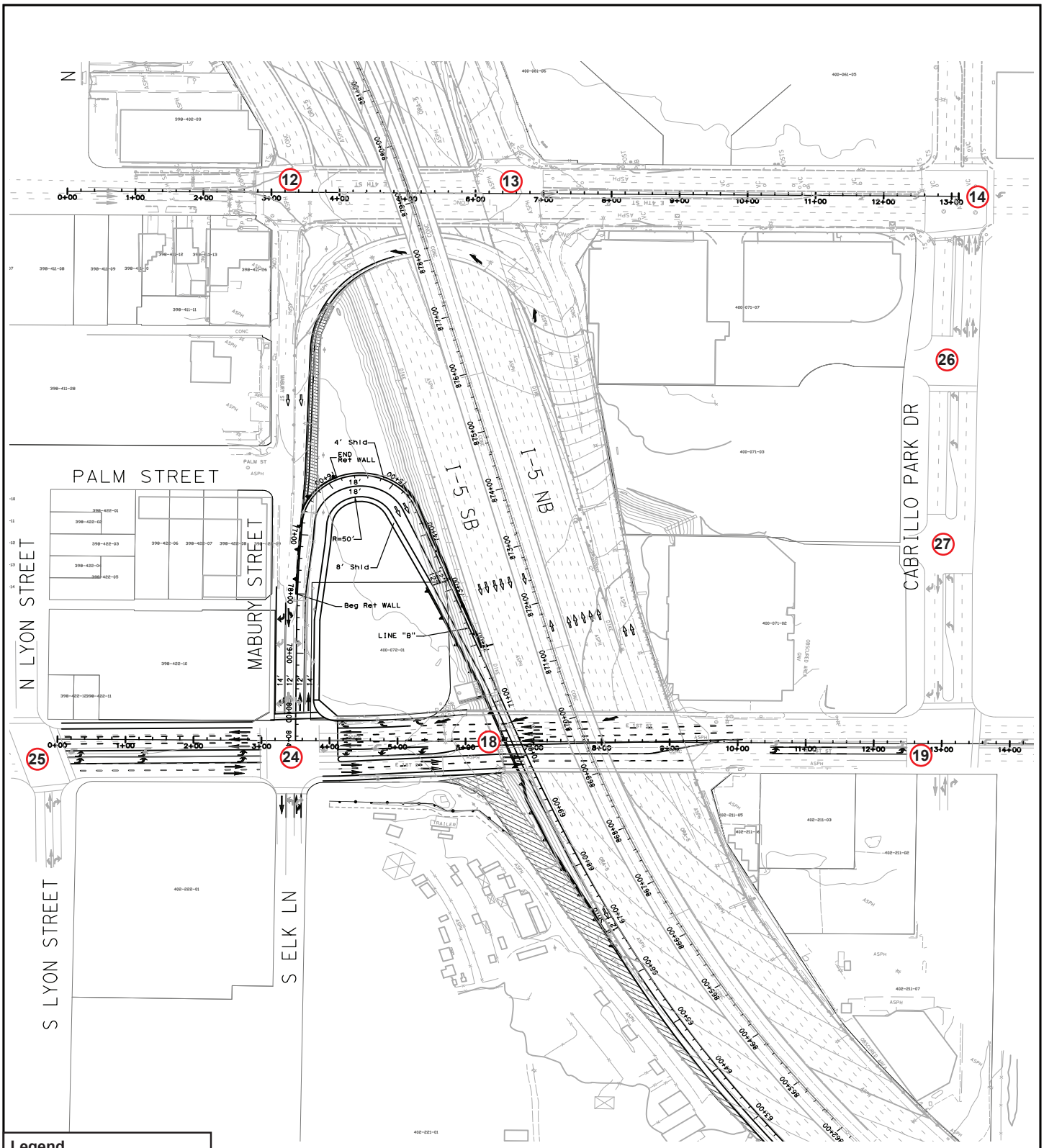
- Restripe portions of First Street, South Elk Lane and Mabury Street to ensure operational continuity.

- Eliminate eastbound and westbound left-turns from First Street to Lyon Street to accommodate the dual left-turn lanes on First Street to the revised on-ramp. Signalize the intersection of First Street/Wright Street (west of Lyon Street).

As a result of these changes, the weave distance between the reconfigured Fourth Street ramp and the downstream SR-55 exit will be lengthened to 2,295 feet (an increase of 740 feet over the existing configuration). Ramp Alternative B improvements are illustrated in Figure 6.

It should be noted that for each affected local intersection, minor modifications to signal timing (no geometric changes) were assumed, where applicable, to account for additional vehicles that were redistributed as part of each of the HOV and Ramp Alternatives. However, with Alternative B, to accommodate vehicles along eastbound First Street destined to the relocated I-5 southbound on-ramp, two left-turn lanes would be needed. To minimize the effect on right-of-way, establishment of the left-turn lanes would require the elimination of the existing eastbound and westbound left-turn pockets at the intersection of First Street/Lyon Street. To accommodate the displaced vehicles at these two movements, a new traffic signal would be installed at the intersection of First Street/Wright Street (located one block to the west). In the westbound direction, vehicles previously making a left-turn to Lyon Street could continue to Wright Street and make a U-turn and then access Lyon Street from eastbound First Street. In the eastbound direction, vehicles previously making a left-turn to Lyon Street would instead turn left at Wright Street, which connects to Lyon Street to the north of First Street.

The Highway Design Manual (HDM) Section 504.7 states that the minimum weaving length, measured as shown on Figures 504.2A and 504.2B of the HDM, shall be 2,000 feet in urban areas, 5,000 feet in rural areas, and 5,000 feet between freeway-to-freeway interchanges and other interchanges. As the weave length between the current First Street on-ramp and the SR-55 off-ramp is currently 1,555 feet, the current configuration does not meet the Caltrans standards. Since the weave length for Ramp Alternative A is proposed to be 2,605 feet and the weave length for Ramp Alternative B is proposed to be 2,295 feet, both of the Ramp Alternatives would meet minimum requirements.



I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED
Figure 6 - Ramp Alternative B Improvements

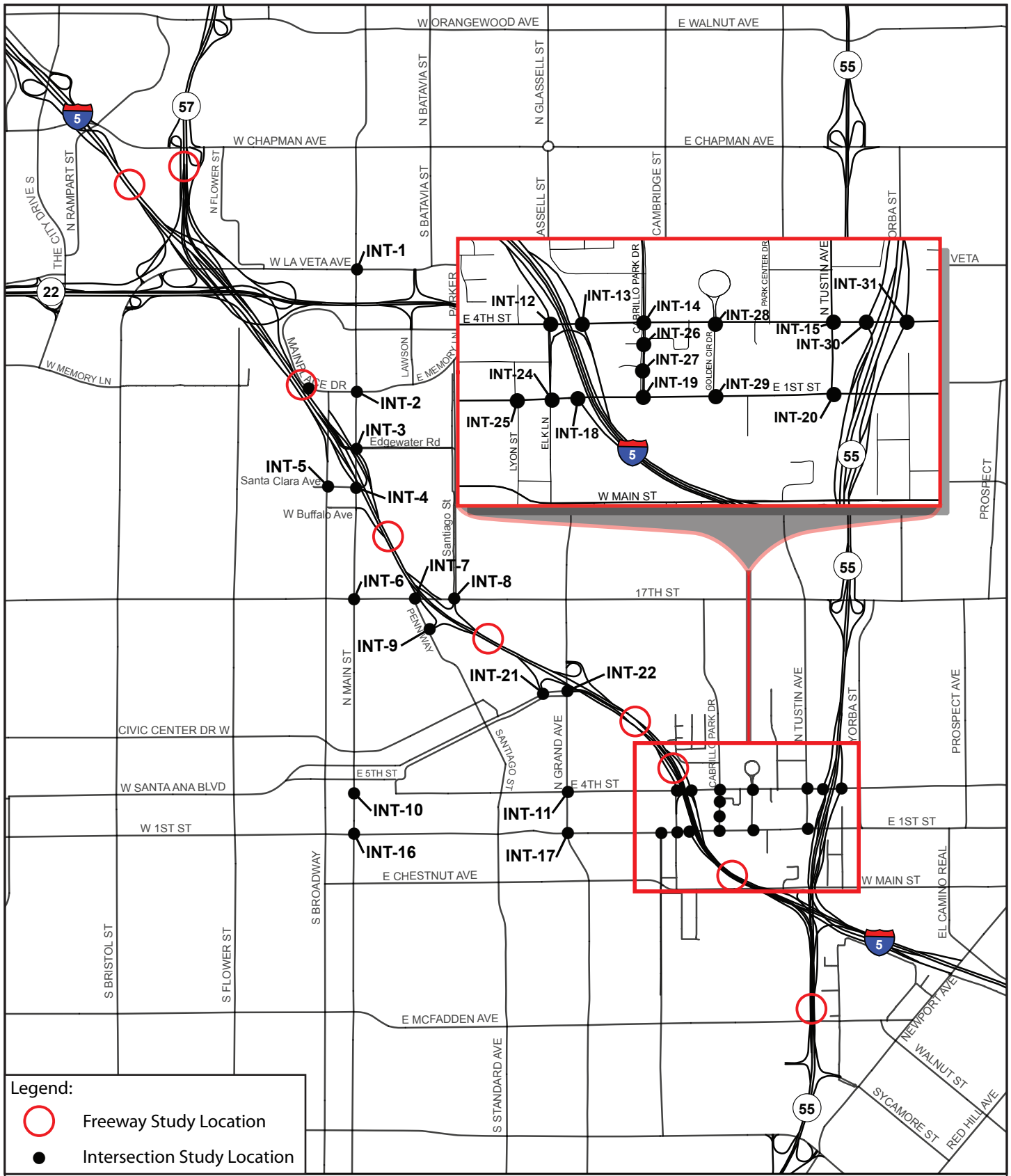
1.2 STUDY AREA

The analysis focuses on locations that could be directly affected by the project alternatives. Overall, a total 16 freeway mainline segments, 15 HOV segments, two weaving segments, five ramp queuing locations, and 31 intersections were evaluated. Note that for analysis purposes, the study area has been separated into those locations included for the HOV Lane Alternatives and those for the Ramp Alternatives.

Figure 7 shows all the analysis locations selected in consultation with Caltrans and appropriate City staff for analysis.

1.3 STUDY PERIODS

Traffic operations were evaluated for each scenario during the peak hour of the weekday AM (7:00 AM to 9:00 AM) and PM (4:00 PM to 6:00 PM) peak periods.



AECOM

I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED
Figure 7 - Study Area Analysis Locations

2.0 METHODOLOGY

This section presents the methodology used to perform the traffic analyses summarized in this report. The methodology described is consistent with the *Caltrans' Guidelines for Transportation Analysis Reports*. The methodology and standards of adjacent Cities were also utilized, where applicable.

2.1 DATA COLLECTION

Intersection Data

Weekday AM and PM peak period intersection turning movement counts were collected for typical weekday conditions from a combination of new counts and from recent studies prepared for the City of Santa Ana. Due to the multiple data sources, intersection counts were balanced to maintain flow between each study location. New intersection turning movement counts were conducted and recorded in 15-minute intervals within each two-hour peak period. In addition, at a subset of the analysis locations, pedestrian crosswalk volumes and vehicle classification counts were collected to determine general area-wide pedestrian volumes and heavy vehicle percentage. Intersection counts can be found in Appendix A. Table 2-1 displays the source and date of intersection counts for each intersection:

Table 2-1: Source of Count Data

ID	Intersection	Count Date	Source of Count Data
1	Main / La Veta	Thursday, September 29, 2011	National Data & Surveying Services
2	Main / Memory	Thursday, September 16, 2010	City Place Sky Lofts Traffic Study[1]
3	Main / Edgewood / I-5	Thursday, June 2, 2011 and Tuesday, June 7, 2011	17th Street LOSSAN Grade Separation Transportation Report
4	Broadway / Santa Clara	Thursday, September 29, 2011	National Data & Surveying Services
5	Main / Santa Clara / I-5	Thursday, September 16, 2010	City Place Sky Lofts Traffic Study[1]
6	Main / 17th	Thursday, September 16, 2010	City Place Sky Lofts Traffic Study[1]
7	Penn / 17th	Thursday, June 2, 2011 and Tuesday, June 7, 2011	17th Street LOSSAN Grade Separation Transportation Report[2]
8	Santiago / 17th	Thursday, June 2, 2011 and Tuesday, June 7, 2011	17th Street LOSSAN Grade Separation Transportation Report[2]
9	Penn / I-5 SB Ramp	Thursday, June 2, 2011 and Tuesday, June 7, 2011	17th Street LOSSAN Grade Separation Transportation Report[2]
10	Main / 4th	Thursday, September 29, 2011	National Data & Surveying Services
11	Grand / 4th	Thursday, September 29, 2011	National Data & Surveying Services
12	I-5 SB Ramp / 4th	Thursday, September 29, 2011	National Data & Surveying Services
13	I-5 NB Ramp / 4th	Thursday, September 29, 2011	National Data & Surveying Services
14	Cabrillo / 4th	Thursday, September 29, 2011	National Data & Surveying Services
15	Tustin / 4th	Thursday, September 29, 2011	National Data & Surveying Services
16	Main / 1st	Thursday, September 29, 2011	National Data & Surveying Services
17	Grand / 1st	Thursday, September 29, 2011	National Data & Surveying Services

ID	Intersection	Count Date	Source of Count Data
18	I-5 SB Ramp / 1st	Thursday, September 29, 2011	National Data & Surveying Services
19	Cabrillo / 1st	Thursday, September 29, 2011	National Data & Surveying Services
20	Tustin / 1st	Thursday, September 29, 2011	National Data & Surveying Services
21	I-5 Ramp / Santa Ana	Wednesday, May 11, 2011	Santa Ana Grade Separation Study Transportation Report[3]
22	Grand / Santa Ana	Wednesday, May 11, 2011	Santa Ana Grade Separation Study Transportation Report[3]
24	Mabury / Elk / 1st	Wednesday, May 9, 2012	National Data & Surveying Services
25	Lyon / 1st	Wednesday, May 9, 2012	National Data & Surveying Services
26	Cabrillo / State Fund	Wednesday, May 9, 2012	National Data & Surveying Services
27	Cabrillo / Xerox Center	Wednesday, May 9, 2012	National Data & Surveying Services
28	Golden Circle / 4th	Wednesday, May 9, 2012	National Data & Surveying Services
29	Golden Circle / 1st	Wednesday, May 9, 2012	National Data & Surveying Services
30	SR-55 SB Ramps / 4th	Wednesday, May 9, 2012	National Data & Surveying Services
31	SR-55 NB Ramps / 4th	Wednesday, May 9, 2012	National Data & Surveying Services

Source: AECOM, 2012
Notes:
[1] City Place Sky Lofts Traffic Study, AECOM, 2010
[2] 17th Street LOSSAN Grade Separation Report, Iteris, 2011
[3] Santa Ana Grade Separation Study Transportation Report, AECOM, 2012

Per Caltrans' request, supplemental counts were conducted at two study locations (the I-5 northbound on-ramp from Main Street and the I-5 southbound on-ramp from First Street) to determine if turning the freeway ramp meters off would appreciably affect the traffic volumes at the movements that directly serve the on-ramps. The purpose of this comparison was to determine whether or not ramp metering at these two locations prohibits the on-ramps from reflecting a true travel demand.

Existing traffic conditions were originally determined based on weekday AM (7:00 AM to 9:00 AM) and PM (4:00 PM to 6:00 PM) peak period counts conducted on Thursday, September 29, 2011 with the all on-ramp meters turned on. The supplement counts were collected with the ramp meters turned off during the same AM and PM peak periods on Wednesday, December 7, 2011.

Overall, it was determined that the traffic volumes at the movements that serve the on-ramps did not substantially vary with the ramp meters turned on or turned off. Therefore, the base traffic volumes counted with the ramp meters on acceptably represent current demand at the ramps, and no adjustments were made to the intersection turning movements.

Freeway Data

Existing freeway mainline and freeway ramp data were obtained directly from the Caltrans Performance Measurement System (PeMS) database. Data were selected from the PeMS database for all Tuesdays, Wednesdays and Thursdays in September 2011 (a total of 13 days), to be consistent with the dates that the majority of the intersection turning

movement counts were conducted. For each day, the weekday AM and PM peak hours (of the morning and evening peak commute periods) were recorded and averaged to develop representative conditions. Average Daily Traffic (ADT) data was collected directly from the Caltrans Performance Measurement System (PeMS) database as well for informational purposes only.

To account for imbalances in the turning movement volumes and to ensure consistent numbers along the study corridor, daily and peak hour data were obtained from multiple mainline locations, and the upstream and downstream on-ramps and off-ramps were added and subtracted. In addition, PeMS ramp data were compared to freeway ramp terminus intersections and adjusted as necessary to replicate the existing conditions as determined in the field.

Average peak hour factors (PHF) were gathered from the PeMS database. For the 13 days observed for the weekday peak hour volume data, the distribution of traffic volumes within the peak hours was also calculated. Overall, the PHF for both the weekday AM and PM peak hours was approximately 0.95; this value was used for all the freeway analyses.

Average freeway truck percentages were gathered from Caltrans 2010 data. Within the study area, truck percentages in the weekday AM and PM peak hours were approximately 6.0 percent; this value was used for all the freeway analyses.

2.2 TRAFFIC FORECASTING

The most current version of OCTA's Orange County Transportation Analysis Model (OCTAM) at the time of the study commencement (version 3.3) was used to develop the Future Year (2040) and Opening Year (2018) traffic forecasts for the I-5 PR/ED. Both the base year (2005) and horizon year (2035) models were reviewed prior to developing the traffic forecasts. The year 2035 forecasts account for the continued development throughout Orange County and the local area,[2] and include the proposed widening and reconfiguration of SR-55 directly south of the project area (e.g., between I-5 and Interstate 405).[3]

Peak Hour Traffic Forecasts

The future 2040 traffic forecasts for freeway mainline and ramps were developed for both the weekday AM and PM peak hours using the difference method contained in the *National Cooperative Highway Research Program (NCHRP) Report 255: Highway Traffic Data for Urbanized Area Project Planning and Design* (Transportation Research Board, December 1982) based on the raw model volumes from the base year (2005) and horizon year (2035) models.

[2] In particular, the forecasts account for the proposed new developments in the vicinity of the First Street on-ramp, namely the Santa Ana Metro East Mixed Use Overlay Zone.
[3] It is anticipated that this project, which would increase mainline capacity and provide auxiliary lanes at key constraint locations along SR-55, will help address some of the congestion on I-5 that results from over-capacity conditions on SR-55.

Since the current OCTAM future model reflects year 2035 conditions, the Future Year (2040) volumes were developed by increasing the year 2035 forecasts to year 2040 by extrapolated the model growth forecast between 2005 and 2035 (i.e., estimating an annual growth rate and applying it the five years between 2035 and 2040). Given that the study area is generally built out, some of the study ramps would be expected to have similar volumes compared to Existing conditions. In addition, OCTAM predicted negative growth for some ramps, as freeway mainline volumes were projected to substantially increase thereby resulting in at-capacity conditions along the mainline with reduced capacity available for vehicles to enter the freeway. At these locations, the ramp volumes were adjusted to be the same as for the Existing conditions as a conservative estimate.

For the I-5 mainline segments, the Future Year (2040) traffic demand was developed using the methodologies described above for the entering locations – south of SR-55 in the northbound direction and north of Chapman Avenue in the southbound direction. Then, the traffic forecasts at the two locations were balanced downstream based on the on- and off-ramp forecasts to develop the traffic volumes for other study freeway mainline segments.

The Future Year 2040 weekday AM and PM peak hour intersection turning movement forecasts were developed using the growth factor method. Roadway segment growth between the OCTAM base year (2005) and horizon year (2035) for the study area was reviewed, and the annual growth factor for each of the roadways in the study area, as well as the entire study area, was calculated. Overall, the growth for most of arterials in the study area was estimated to be about 0.4 percent to 0.5 percent per year during peak periods. These corridor-specific growth rates were applied to the existing turning movement volumes to obtain the 2040 turning movement forecasts for study intersections.

The Opening Year (2018) peak hour traffic forecasts were developed for freeway mainline, ramps, and study intersections using interpolation between the existing and forecasted Future Year (2040) traffic volumes.

Average Daily Traffic (ADT) Forecasts

In addition, ADT forecasts were developed for freeway mainline segments and study intersections for Opening Year (2018) and Future Year (2040) conditions. The ADT forecasts for freeway mainline segments were developed using the difference method described above. For study intersections, the ADT were forecasted using the k factor adjustment method. The k factor represents the proportion of ADT occurring in the peak hour and was calculated by dividing the existing peak hour volumes by existing ADT of each intersection. The calculated k factor was then applied to the forecasted Opening Year (2018) and Future Year (2040) peak hour intersection volumes to develop ADT values at those locations. Overall, the ADT growth for the study area is about 0.35 percent per year. At locations where negative growth was projected to occur, the volumes were conservatively kept the same as existing.

2.3 VOLUME DEVELOPMENT

2.3.1 HOV LANE ALTERNATIVES

The existing I-5 freeway HOV lanes currently have two locations at which bottlenecks constrain the ability of vehicles to proceed through the HOV lanes.

In the I-5 northbound direction, immediately north of the Grand Avenue HOV off-ramp, the HOV facility transitions from two lanes to one lane. Based on a review of PeMS data, average speed during the peak hours at these locations was approximately 15 mph (as compared to the free-flow speed of 65 mph) indicating the severity of the bottleneck. In addition, PeMS data revealed the highest amount of peak hour vehicles able to proceed through the HOV lane after the Grand Avenue HOV off-ramp is 1,900 vehicles.

In the I-5 southbound direction, at the SR-57 on-ramp, the HOV facility also transition from two lanes to one lane. At this location, similarly to the northbound direction, a review of PeMS data indicates speed at this bottleneck is approximately 15 mph and the maximum number of vehicles able to proceed through this location during the peak hour is 1,550 vehicles.

Therefore, for Opening Year (2018) No Build and Future Year (2040) No Build scenarios, a constraint was applied to the volumes at these two locations to reflect true HOV operations. For the Build project scenarios, Alternatives 2A, 2B, 5A, and 5B, where the HOV facilities are proposed to be two lanes at these locations, this constraint was eliminated and additional volumes were projected to be able to proceed through the bottlenecks and the subsequent downstream analysis locations.

Compared to the No Build Alternatives, the HOV Lane Alternatives 2A and 5A would have the following additional HOV lane volumes (all volumes taken at the start point of the additional HOV lane segment), and presented in vehicles per hour (vph):

- Opening Year (2018)
    - Weekday AM peak hour: southbound = 1,070 vph; northbound = 130 vph
    - Weekday PM peak hour: southbound = 1,025 vph; northbound = 310 vph
- Future Year (2040)
    - Weekday AM peak hour: southbound = 2,035 vph; northbound = 500 vph
    - Weekday PM peak hour: southbound = 1,545 vph; northbound = 1,340 vph

In addition, for all Build Alternatives, OCTAM output also indicates that the additional HOV capacity would attract additional users due to the elimination of the bottlenecks and capacity constraints. The following are the increases in corridor HOV volumes for the HOV Lane Alternatives as compared to the No Build Alternative:

- Opening Year (2018)
    - Weekday AM peak hour: southbound = 270 vph; northbound = 130 vph
    - Weekday PM peak hour: southbound = 115 vph; northbound = 270 vph
- Future Year (2040)
    - Weekday AM peak hour: southbound = 1,110 vph; northbound = 500 vph
    - Weekday PM peak hour: southbound = 450 vph; northbound = 1,110 vph

With the Build alternatives, the additional HOV lane capacity would result in higher HOV lane volumes as compared to No Build. Therefore, there would be the potential for a corresponding decrease in volume within the I-5 mainline. However, OCTAM output indicated that any diversion of vehicles from the general purpose lanes to the HOV lanes would be replaced by rerouted trips from other facilities or from local streets. As a result, it was conservatively estimated that local street and I-5 mainline volumes would not change between the No Build and Build scenarios.

For HOV Lane Alternatives 2B and 5B, the designs would eliminate the Main Street I-5 HOV ramps and no longer allow high-occupancy vehicles to directly enter and exit the I-5 freeway at this location. Currently, the southbound HOV off-ramp has a volume of 144 vph during the weekday AM peak hour and 65 vph during the weekday PM peak hour; the northbound on-ramp has a volume of 51 vph during the weekday AM peak hour and 314 vph during the weekday PM peak hour. In the future, these HOV ramps were projected to have additional use due to general background growth: additional northbound 14 AM peak hour vehicles and 41 PM peak hour vehicles and an additional southbound 36 AM peak hour vehicles and 15 PM peak hour vehicles in the Opening Year (2018); and an additional northbound 54 AM peak hour vehicles and 171 PM peak hour vehicles and an additional southbound 146 AM peak hour vehicles and 70 PM peak hour vehicles in the Future Year (2040).

Eliminating these ramps would affect I-5 HOV users previously accessing I-5 at this location; however, based on origin and destination volumes from OCTAM, most of the HOV users along the I-5 Freeway (and the connecting SR-22 and SR-57 Freeways) are long distance in nature. Therefore, OCTAM projected that the elimination in direct access at Main Street would not cause an appreciable percentage of drivers to shift from HOV to single-occupant vehicles (SOV), although it would alter how local I-5 HOV users access the HOV lanes. Note that if drivers did choose to switch from HOVs to SOVs, it could result in a minor increase in local traffic volumes; however, any increase in volumes would be relatively small considering the current and projected future volumes in the area.

At a local level, Alternatives 2B and 5B would cause high-occupancy vehicles to use other upstream or downstream mainline ramps, affecting volumes at other freeway ramps and local street intersections. Southbound I-5 HOV vehicles previously exiting the HOV lane at Main Street would be required to exit the HOV lane upstream or downstream by entering the general purpose lanes and utilizing the mainline ramps to exit the freeway (such as at La Veta Avenue, Main Street, Broadway, or 17th Street) depending on the

ultimate destination of their trip. For example, with the removal of the southbound Main Street HOV off-ramp, a southbound HOV lane user destined to the Discovery Science Center would likely exit the HOV lane upstream near Orangewood Avenue, exit the mainline at the Broadway off-ramp, turn left to Santa Clara Avenue, and then turn left onto Main Street. Similarly, the Main Street on-ramp vehicles previously entering the I-5 HOV lane would need to seek other access points by entering the upstream or downstream mainline ramps and utilizing HOV access points along the mainline to filter into the HOV lane (such as at Chapman Avenue, Main Street or 17th Street) depending on their trip origin. For example, with the removal of the northbound Main Street HOV on-ramp, a northbound HOV lane user leaving the Discovery Science Center would likely travel southbound on Main Street and access the I-5 mainline from the on-ramp at Main Street/Santa Clara Avenue, and then enter the HOV lane just north of Broadway overcrossing under Alternative 2B and near Orangewood Avenue under Alternative 5B. The distribution of these vehicle trips on the mainline, HOV, and intersections was incorporated for Alternatives 2B and 5B. Information regarding the projected rerouting of the Main Street HOV on- and off-ramp users is included in Appendix B.

Detailed traffic volume development worksheets are included in Appendix B.

2.3.2 RAMP ALTERNATIVES

The Ramp Alternatives A and B are anticipated to affect intersection operations on the local streets and the freeway mainline immediately adjacent to the project site.

With Ramp Alternative A, both entering and exiting vehicles for both northbound and southbound I-5 would be affected as a result of the following three geometry changes:

- Elimination of the “horseshoe” ramp, which connects the I-5 northbound off-ramp at Fourth Street to First Street.
- Closure of Mabury Street between Fourth Street and First Street to through traffic.
- Relocation of the I-5 southbound on-ramp from First Street to Fourth Street.

To account for these roadway changes, the affected weekday AM and PM peak hour vehicles were reassigned to nearby parallel facilities.

In addition, the elimination of the “horseshoe” ramp and the relocation of the on-ramp from First Street to Fourth Street may affect the freeway access patterns for vehicles connecting to and from locations between I-5 and SR-55 (east of the study area). Therefore, it was anticipated that a portion of vehicles (estimated to be between 50 and 100 during either peak hour) would reroute to SR-55 and its Fourth Street on- and off-ramps.

With Ramp Alternative B, the primary effect to vehicles entering and exiting northbound and southbound I-5 would be the result of the following geometric change:

- Establishment of a loop on-ramp at First Street and the elimination of access to the ramp from southbound Mabury Street.

To account for this roadway change, the affected weekday AM and PM peak hour vehicles were reassigned along the local roadway network to access the alternative freeway on-ramp entrance location.

In addition, the elimination of access to the First Street on-ramp from Fourth Street via Mabury Street may affect the freeway access patterns for vehicles coming from locations between I-5 and SR-55 (east of the study area). Therefore, it was anticipated that a portion of vehicles would reroute to SR-55 and its Fourth Street on-ramp. This portion of vehicles (estimated to be between 10 and 20 during either peak hour) was based on a review of current intersection turning movement volumes, area origins/destinations, and average travel distances.

Any changes in freeway mainline volumes as a result of HOV Lane Alternatives 2A, 2B, 5A, and 5B, would be minimal at the Fourth and First Street ramp locations as these study area locations are located a sufficient distance (over 0.5 miles) as to not be affected by the alternatives.

Detailed traffic volume development worksheets are included in Appendix B.

2.4 INTERSECTION CAPACITY ANALYSIS

In agreement with OCTA and Caltrans, peak hour traffic operations at the intersections were analyzed using the 2000 *Highway Capacity Manual (*HCM*)* operations analysis methodology. Trafficware's Synchro Version 7 software was used to analyze intersection operations consistent the 2000 HCM methodology. The HCM approach provides an accurate assessment of the effect of signal operational changes, such as signal timing and phasing, cycle lengths, signal progression and coordination, clearance intervals, and others, on the evaluation of intersection operations. However, the HCM approach does not take into account effects of queuing from other intersections. Signal timing plans were provided by Caltrans and the City of Santa Ana; locations where plans were not available were instead estimated from field data.

With the HCM methodology, LOS thresholds are based on the average delay incurred by vehicles traveling through the intersection. This methodology determines the capacity of each lane group approaching the intersection. The LOS is based on average delay (in seconds per vehicle) for the various movements within the intersection. A combined weighted average delay and LOS are presented for the intersection.

Intersection LOS ranges from LOS A, which indicates free flow or excellent conditions with short delays, to LOS F, which indicates congested or overloaded conditions with extremely long delays. LOS definitions for signalized intersections are described in Table 2-2. The LOS was calculated using Trafficware's Synchro software package.

Delay for signalized intersections operating at LOS F is typically reported as "greater than 80.0 seconds," as 80.0 seconds is generally considered the limit of the meaningful range for the analysis methodology. For informational purposes, the V/C ratio is also shown in this report.

Table 2-2: Intersection Level of Service Definitions

Level of Service	Average Delay per Vehicle (seconds/vehicle) – Signalized Intersections
A	< 10.0
B	> 10.0 and < 20.0
C	> 20.0 and < 35.0
D	> 35.0 and < 55.0
E	> 55.0 and < 80.0
F	> 80.0

Source: *Highway Capacity Manual*, Transportation Research Board, 2000.

2.5 FREEWAY CAPACITY ANALYSIS

Peak hour traffic operations for mainline, weaving, and HOV segments were analyzed using the 2010 HCM operation analysis methodologies.

Freeway Segments: A basic freeway segment is a freeway mainline segment that is not within a ramp influence area (i.e., within 1,500 feet of a ramp) or within a weaving segment. Adding or dropping a lane results in the termination of a basic segment. Basic segments do not include adjacent HOV lanes because traffic is permitted to move between HOV lanes and mixed-flow lanes only at specified locations. The global settings used in the analysis include a peak-hour factor of 0.95; a freeway flow speed of 65 miles per hour (mph) for the I-5, SR-55, and SR-57 Freeway segments; and a lane capacity of 2,100 vph (based on a calculation of maximum observed throughput along both northbound and southbound I-5 in the study area, as obtained from PeMS).

The mainline analysis was conducted using the Highway Capacity Software, 2010 compliant with the 2010 HCM. For freeway segments, the measure used to evaluate LOS is density, and the LOS density ranges are listed in Table 2-3. As stated in the HCM, the upper value shown for LOS E (45 passenger cars per mile per lane – pc/mi/ln) is the maximum density at which sustained flows at capacity can to occur. Flow breakdown and congestion as represented by LOS F occurs when queues begin to form on the freeway. Density tends to increase sharply within the queue and may be considerably higher than the maximum 45 pc/mi/ln for LOS E. When freeway demand conditions exceed capacity, forced flow results, and the formulas used to estimate density are no longer applicable. Therefore, estimates for freeway mainline density are not provided for LOS F conditions.

Weaving Sections: A weaving segment is a freeway mainline segment in which two streams of traffic must cross within less than 2,500 feet, such as in an auxiliary lane connecting an on-ramp to an off-ramp. Weaving segments are formed when a merge area is closely followed by a diverge area, or when an on-ramp is closely followed by an off-ramp and the two are connected by an auxiliary lane. For weaving sections, two analysis approaches were used: the 2010 HCM methodology and the Leisch method[4]. Using the 2010 HCM methodology for weaving segments, the measure used to evaluate LOS is density. LOS F represents overflow conditions with high density and congestion that occur at a lower density than basic freeway segments because of the additional turbulence of vehicular lane changes as shown in Table 2-3. In addition to density, volume-to-capacity ratios (V/C) were calculated to provide an indication of the change in conditions with and without the project components. The global settings used in the analysis include a peak-hour factor of 0.95; a freeway flow speed of 65 miles per hour (mph) for the I-5, SR-55, and SR-57 Freeway segments; and a lane capacity of 2,100 vph.

The basic input data for conducting a weaving analysis includes the type of weaving segment (defined by the number of necessary lane changes), length of the weaving segment, number of lanes in the freeway, peak-hour through volumes on the freeway, vehicular volume entering the freeway from the weaving segment, vehicular volume exiting the freeway through the weaving segment, and the volume of vehicles entering and exiting the weave segment without fully entering the freeway. Current vehicular patterns and output from OCTAM was used to estimate the percentage of vehicles entering and exiting the weaving segment without changing lanes.

HOV Lanes: The definition of an HOV lane segment is essentially the same as a basic freeway segment. However, since the HCS software cannot analyze single-lane facilities; with the approval of Caltrans, as under the Existing and No Build scenarios, a volume-to-capacity (V/C) ratio was calculated for the HOV segments. For consistency with the HOV Lane Alternatives that add an additional HOV lane, this same methodological approach was applied to all HOV lane analyses.

The global settings used in the analysis include a peak-hour factor of 0.95; a freeway flow speed of 65 mph, and a lane capacity of 1,900 vph (based on a calculation of maximum observed throughput along both northbound and southbound HOV lanes along I-5 in the study area, as obtained from PeMS). The density and V/C thresholds for the freeway and HOV segments are shown in Table 2-3.

[4] The Leisch method was developed to determine the length of weaving sections for both freeways and collector-distributor roads. The Leisch weaving charts, as described in Section 504.7 of the Highway Design Manual (HDM), determine the LOS for the weaving volumes for the length of the weaving section.

Table 2-3: Freeway Level of Service Definitions

Level of Service	Density (vehicles per lane-mile)		Volume/Capacity Ratio	Description
	Basic Freeway Section[1]	Weave Section[2]	HOV Section[2]	
A	≤ 11	≤ 10	≤ 0.30	Free-flow speeds prevail. Vehicles are almost completely unimpeded in their ability to maneuver within the traffic stream.
B	11 to 18	10 to 20	0.30 to 0.50	Free-flow speeds are maintained. The ability to maneuver with the traffic stream is only slightly restricted.
C	18 to 26	20 to 28	0.50 to 0.71	Flow with speeds at or near free-flow speeds. Freedom to maneuver within the traffic stream is noticeably restricted, and lane changes require more care and vigilance on the part of the driver.
D	26 to 35	28 to 35	0.71 to 0.89	Speeds decline slightly with increasing flows. Freedom to maneuver with the traffic stream is more noticeably limited, and the driver experiences reduced physical and psychological comfort.
E	35 to 45	35 to 43	0.89 to 1.00	Operation at capacity. There are virtually no usable gaps within the traffic stream, leaving little room to maneuver. Any disruption can be expected to produce a breakdown with queuing.
F	> 45	> 43	> 1.00	Represents a breakdown in flow.

Source:
[1] *Highway Capacity Manual*, Transportation Research Board, 2010.
[2] *Highway Capacity Manual*, Transportation Research Board, 2000.

2.6 FREEWAY OFF-RAMP QUEUING ANALYSIS

The methodology for evaluating queuing on freeway off-ramps considers the length of vehicles queued as a result of the controlling off-ramp intersection. Both 50th and 95th percentile queue lengths were determined based on the 2000 HCM methodology using the results of the intersection LOS output. In general, Caltrans considers potential impacts if the project results in additional vehicles at the controlling intersection that cause the 95th percentile off-ramp queue to exceed the available queuing space, or if the project add additional vehicles to a location where the off-ramp queue already spills back to the freeway mainline.

2.7 STANDARDS OF SIGNIFICANCE

For freeway mainline segments, the upper threshold for level of service is LOS E, which represents the maximum density at which sustained flows at capacity are expected to occur. Failure, breakdown, congestion, and LOS F occur when queues begin to form on the freeway. Density tends to increase sharply within the queue and may be considerably higher than the maximum value of 45 pc/mi/ln.

For the HOV lane analysis, two evaluations were conducted. First, an HOV lane is considered to operate unacceptably at LOS E conditions (based on a capacity of 1,900 vphpl). Second, Caltrans' goal is to maintain free flowing conditions within the HOV lane. Therefore, Caltrans recommends a maximum HOV facility volume of 1,600 vphpl for one lane segments and 1,750 vphpl for two lane segments (3,500 vph in total). Locations that have volumes that exceed these recommendations are therefore indicated in the analysis.

The analysis intersections are located within the Cities of Orange, Santa Ana and Tustin. Each of these jurisdictions' policies on acceptable level of service are presented below:

- The City of Orange's General Plan Circulation Element establishes LOS D as the minimum acceptable level of service for intersections in the City. The Orange County Congestion Management Program (CMP) also establishes LOS E as the maximum level of service for CMP facilities. However, no study area intersections are within the County's CMP facilities. Therefore, the LOS D threshold applies to all study intersections within Orange.

- The City of Santa Ana's General Plan Circulation Element establishes LOS D as the minimum acceptable level of service for intersections in the City, except in major development areas (MDA). The City of Santa Ana considers LOS E as the threshold for an acceptable level of service for intersections located within an MDA. The Orange County CMP also establishes LOS E as the maximum level of service for CMP facilities. However, no study area intersections are within the County's CMP facilities, nor are any intersections located within an MDA. Therefore, the LOS D threshold applies to all study intersections within Santa Ana.

- The City of Tustin has established LOS D as a threshold standard to assess peak hour intersection service levels. However, consistent with the CMP guidelines, intersections along designated Smart Streets (Irvine Boulevard, Edinger Avenue and Jamboree Road) have a higher threshold of LOS E. Since no study intersections are along any of those three streets, the LOS D threshold applies to all study intersections within Tustin.

Therefore, all jurisdictions use LOS D as a threshold standard for the determination of operational performance of the intersections in the study area.

3.0 EXISTING CONDITIONS

This section discusses the Existing conditions in the study area. Existing traffic data were assembled for the highway system components as previously discussed (freeway mainline segments, HOV segments, ramps, and intersections), and the performance procedures described in the previous section applied. The following are the results for each system component.

3.1 EXISTING FREEWAY MAINLINE PERFORMANCE

Table 3-1 and Table 3-2 show the mainline LOS analysis under Existing conditions. Figure 8 displays the mainline volumes at each of the study area locations. As shown in Table 3-1 and Table 3-2 during the weekday AM peak hour, 6 of the 12 analysis segments on the I-5 Freeway currently operate at LOS F, and 2 of the 12 currently operate at LOS E. During the weekday PM peak hour, 2 of the 12 analysis segments on the I-5 Freeway currently operate at LOS F, and 5 of the 12 currently operate at LOS E. For the freeway segments relevant to the Ramp Alternatives analysis, all locations in the weekday AM peak hour currently operate at LOS E or F; two locations in the weekday PM peak hour currently operate at LOS E or F.

In addition to the evaluation of the density of the mainline segments, the existing peak hour speeds (as obtained from the PeMS data) are also documented. As the table indicates, the majority of the freeway sections operate at or near the free-flow speed of 65 mph. At a few locations, the speeds drop to between 30 and 40 mph, indicating congested conditions consistent with LOS F conditions.

HCS worksheets can be found in Appendix C.

Table 3-1: Freeway Mainline LOS Summary – Existing Conditions – HOV Lane Alternative Analysis Locations

Map Ref #	Locations		Lanes		AM Peak Hour				PM Peak Hour			
			ML	Aux	Speed	Volume	Density[1]	LOS	Speed	Volume	Density[1]	LOS
1	SR-57 between Chapman off-ramp and SR-22 off-ramp	SB	3	0	**43**	**7,323**	**>45.0**	**F**	**55**	**7,523**	**67.4**	**F**
2	I-5 between Chapman on-ramp and SR-22 off-ramp	SB	5	2	47	8,763	30.2	D	65	7,746	26.0	C
5	I-5 between Main on-ramp and 17th/Penn off-ramp	SB	5	1	38	9,585	34.6	D	59	9,340	33.2	D
6	I-5 between 17th on-ramp and Santa Ana off-ramp	SB	5	1	**49**	**10,102**	**38.2**	**E**	**61**	**9,705**	**35.4**	**E**
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**43**	**9,794**	**36.0**	**E**	**59**	**9,905**	**36.8**	**E**
9	I-5 between Fourth off-ramp and First Street on-ramp	SB	5	1	39	9,061	31.7	D	57	9,429	33.7	D
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**62**	**11,583**	**>45.0**	**F**	43	9,466	33.9	D
6	I-5 between Grand Ave on-ramp and 17th off-ramp	NB	5	1	**63**	**10,920**	**>45.0**	**F**	39	8,890	30.8	D
5	I-5 between 17th on-ramp and Main/Broadway off-ramp	NB	5	1	**36**	**11,408**	**>45.0**	**F**	**23**	**10,088**	**38.1**	**E**
4	I-5 between Main on-ramp and SR-22 exit	NB	4	1	**68**	**9,225**	**>45.0**	**F**	**62**	**8,915**	**>45.0**	**F**
2	I-5 between SR-22 on-ramp and Chapman off-ramp	NB	5	1	69	9,244	32.6	D	**66**	**10,064**	**37.9**	**E**
1	SR-57 between Chapman off-ramp and Chapman on-ramp	NB	3	0	**64**	**7,273**	**60.3**	**F**	**51**	**6,069**	**39.1**	**E**

Source: AECOM, 2012.
Notes:
GP – General Purpose Lane; Aux – Auxiliary Lane
[1] Density is shown in passenger cars / mile / lane (pc/mi/ln)
Bold = Level of Service (LOS) "E" or "F" (mainline)

Table 3-2: Freeway LOS Summary – Existing (2011) Conditions – Ramp Alternative Analysis Locations

Map Ref #	Locations		Lanes		AM Peak Hour				PM Peak Hour			
			ML	Aux	Speed	Volume	Density[1]	LOS	Speed	Volume	Density[1]	LOS
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**43**	**9,794**	**36.0**	**E**	**59**	**9,905**	**36.8**	**E**
10	I-5 between First on-ramp and SR-55 off-ramp	SB	5	1	**61**	**10,250**	**>45.0**	**F**	**53**	**10,576**	**>45.0**	**F**
10	I-5 between SR-55 on-ramp and First/Fourth off-ramp	NB	5	1	**63**	**11,885**	**>45.0**	**F**	47	9,314	33.1	D
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**62**	**11,583**	**>45.0**	**F**	43	9,466	33.9	D

Source: AECOM, 2012.
Notes:
GP – General Purpose Lane; Aux – Auxiliary Lane
[1] Density is shown in passenger cars / mile / lane (pc/mi/ln)
Bold = Level of Service (LOS) "E" or "F" (mainline)

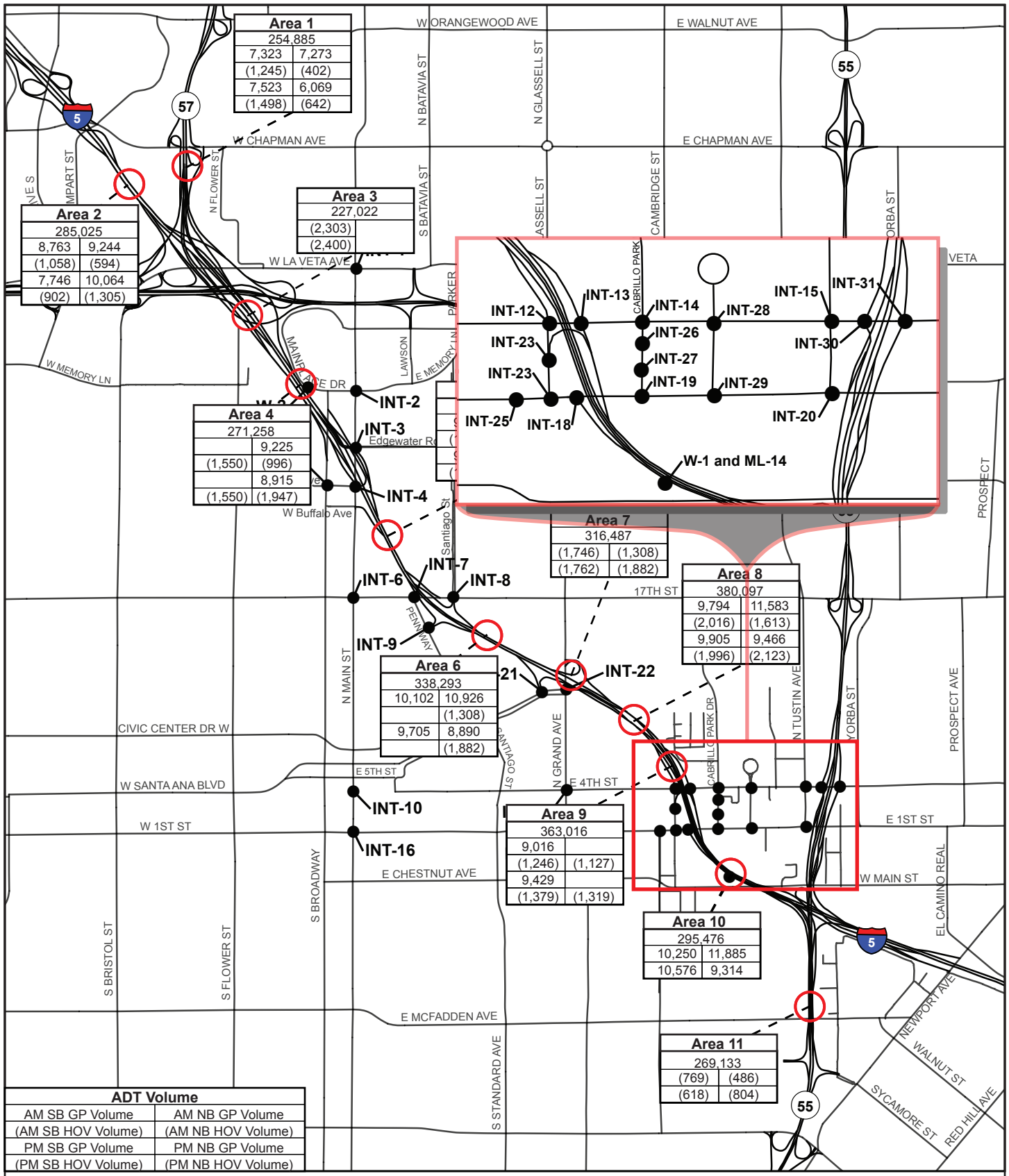
3.2 EXISTING HOV LANE PERFORMANCE

Existing freeway HOV volumes are shown in Figure 8, and the HOV analysis results are summarized in Table 3-3. The current weekday AM and PM peak hour HOV volumes by direction and measures of effectiveness are included in Table 3-3.

The SAFETEA-LU *Federal Determination Report: ILEV/Hybrids on HOV Facilities in California* provides a framework to guide the future development and operation of this portion of the transportation network into a coordinated, connected and commonly recognizable system for California. Federal law (Section 166(d)(2)(B)) of SAFETEA-LU defines a degraded facility as one where vehicles fail to maintain a minimum average operating speed of 45 mph for a HOV facility with a speed limit of 50 mph or greater, 90 percent of the time over a consecutive 180-day period (6 months) during morning or evening weekday peak hour periods or both. According to these definitions, the HOV lane northbound and southbound along the I-5 between the SR-55 and SR-57 are considered degraded facilities during one or both of the AM and PM peak hours.

As noted previously, there is a severe bottleneck where the HOV lane from I-5 southbound connects with the HOV lane from SR-57 southbound. At this location, the two HOV lanes merge into one HOV lane. Based on review of Caltrans PeMS data, the maximum throughput at this bottleneck location is 1,550 vehicles per hour. North of the bottleneck, there is an un-served demand of about 750 vehicles during the weekday AM peak hour and 850 vehicles during the weekday PM peak hour, resulting in substantial delays to HOV lane users and LOS F conditions. In addition, PeMS data indicate that during the peak hours, average vehicular speeds at the bottleneck location was reduced to between 15 and 20 miles per hour. Note that since this bottleneck restricts downstream volumes, analysis locations to the south tend to operate under capacity. To account for these bottleneck conditions, the HOV lane operations were assessed at the actual merge point (with the full volumes along both entering HOV facilities and one lane of capacity) and downstream of the merge point (with the capacity-constrained volumes and one lane of capacity).

As shown in Table 3-3, two analysis HOV lane segments currently operate at LOS E or F during the AM peak hour, and five analysis HOV lane segments currently operate at LOS E or F during the PM peak hour. In addition to the two bottleneck locations, there are currently three other locations where the HOV volumes approach or slightly exceed capacity in the weekday PM peak hour: within the southbound HOV lane at the entrance from the general purpose lane near Santa Ana Boulevard; within the northbound HOV lane where the two HOV lanes merge to one HOV lane just north of the Grand Avenue HOV lane off-ramp; and within the northbound HOV lane just north of the Main Street HOV lane on-ramp. It should be noted that there are several segments that operate above the Caltrans' recommended HOV lane volume of 1,600 vphpl for one-lane segments and 1,750 vphpl (3,500 vph total) for two-lane segments. HOV lane calculations are provided in Appendix D.



I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED
Figure 8 - I-5 Freeway Volumes – Existing (2011) Conditions

Table 3-3: HOV LOS Summary – Existing (2011) Conditions

Map Ref #	Location		# of Lanes	AM Peak Hour				PM Peak Hour			
				Speed[1]	Volume	Capacity (V/C)	LOS	Speed[1]	Volume	Capacity (V/C)	LOS
1	SR-57 north of I-5 HOV merge	SB	1	45	1,245	0.66	C	49	1,498	0.79	D
2	I-5 north of SR-57 HOV merge	SB	1	51	1,058	0.56	C	61	902	0.47	B
3	I-5 at SR-57 HOV merge	SB	1	**32**	***2,303***	***1.21***	***F***	***50***	***2,400***	***1.26***	***F***
4	I-5 between SR-57 HOV merge and Main HOV off-ramp[2]	SB	1	32	1,550	0.82	D	50	1,550	0.82	D
5	I-5 between Main HOV off-ramp and HOV entrance south of Lincoln overcrossing	SB	1	60	1,406	0.74	D	63	1,485	0.78	D
7	I-5 between HOV entrance and Grand HOV on-ramp	SB	1	**57**	***1,746***	***0.92***	***E***	***57***	***1,762***	***0.93***	***E***
8	I-5 between Grand HOV on-ramp and SR-55 HOV diverge	SB	2	55	2,016	0.53	C	56	1,996	0.53	C
9	I-5 south of SR-55 HOV diverge	SB	1	53	1,246	0.66	C	52	1,379	0.73	D
11	SR-55 south of I-5 HOV diverge	SB	1	53	769	0.40	B	52	618	0.33	B
11	SR-55 south of I-5 HOV merge	NB	1	54	486	0.26	A	42	804	0.42	B
9	I-5 south of SR-55 HOV merge	NB	1	63	1,127	0.59	C	38	1,319	0.69	C
8	I-5 between SR-55 HOV merge and Grand HOV off-ramp	NB	2	61	1,613	0.42	B	49	2,123	0.56	C
7	I-5 at HOV lane merge (2 to 1 lane)	NB	1	62	1,308	0.69	C	***48***	***1,882***	***0.99***	***E***
6	I-5 between HOV lane merge and HOV lane exit north of Lincoln overcrossing	NB	1	65	1,308	0.69	C	***56***	***1,882***	***0.99***	***E***
5	I-5 between HOV exit and Main HOV off-ramp	NB	1	69	945	0.50	B	*58*	*1,633*	*0.86*	*D*
4	I-5 between Main HOV on-ramp and SR-57 diverge	NB	1	63	996	0.52	C	***56***	***1,947***	***1.02***	***F***
2	I-5 north of SR-57 diverge	NB	1	64	594	0.31	B	59	1,305	0.69	C
1	SR-57 north of I-5 HOV diverge	NB	1	62	399	0.21	A	57	642	0.34	B

Source: AECOM, 2012.
Notes: **Bold** indicates HOV segment operating at LOS E/F. *Italics* indicate locations where the HOV lane has greater than 1,600 vphpl for 1-lane segment; 1,750 vphpl for 2-lane segment.
[1] Existing speed, in miles per hour.
[2] Bottleneck location which constrains downstream volumes.

It should be noted that the similar capacity constraint for northbound HOV lane flows (where the I-5 northbound and SR-55 northbound HOV lanes merge north of the Grand Avenue direct HOV exit) is not reached under Existing conditions; therefore, this potential bottleneck does not affect operations during the weekday AM and PM peak hours under Existing conditions.

Note that HOV segments located near the Ramp Alternatives analysis locations were not evaluated as the design of the alternatives would not affect HOV volumes at those locations.

HOV lane calculations are included in Appendix D.

3.3 EXISTING WEAVING PERFORMANCE

The I-5 Freeway northbound between the Main Street on-ramp and the SR-22 exit operates at LOS E conditions during both the weekday AM and PM peak hours. In general, these conditions are due to the weaving section being near capacity (primarily from the high volumes destined to the SR-22 freeway). As a result, this section of I-5 experiences congestion during peak hours, including delays to mainline users and queues at the Main Street on-ramp, as shown by the unacceptable LOS in Table 3-4.

The I-5 Freeway southbound between the First Street on-ramp and the SR-55 exit operates at LOS F conditions during both the weekday AM and PM peak hours, as shown in Table 3-4. In general, these conditions are due to the weaving section being over capacity (the total volume of freeway mainline, on-ramp and exit volumes are higher than can typically be processed) and backups from southbound SR-55. (Note that a project is currently underway to evaluate improvements on SR-55 south of the I-5 merge. These improvements were included in the Opening Year (2018) and Future Year (2040) analyses.) As a result, this section of I-5 experiences congestion during peak hours, including delays to mainline users and queues at the First Street on-ramp.

Table 3-4: HCM Weaving LOS Summary – Existing (2011) Conditions – HOV Lane Alternative Analysis Locations

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**37.0**	**E**	**0.86**	**39.7**	**E**	**0.88**
SB I-5 between First on-ramp and SR-55 off-ramp	SB	1,555	**>45.0**	**F**	**1.16**	**>45.0**	**F**	**1.16**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

A second methodology using the Leisch method from the Highway Design Manual, as previously described, was utilized to analyze the weaving section and is shown in Table 3-5. Based on HDM, both weaving sections operates at LOS F conditions during the weekday AM and PM peak hours. Weaving calculations using the HDM methodology are included in Appendix E.

Table 3-5: HDM Weaving LOS Summary – Existing (2011) Conditions – HOV Lane Alternative Analysis Locations

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**F**	**F**
SB I-5 between First on-ramp and SR-55 off-ramp	SB	1,555	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

In addition to these key I-5 mainline weave locations, there are two weave/merge locations within the HOV lanes. Along the southbound I-5 HOV lane, there is an entrance from the I-5 southbound mainline and an entrance at the Grand Avenue HOV direct on-ramp, followed by the diverge between the I-5 southbound and SR-55 southbound HOV lanes. Along the northbound I-5 HOV lane, there is an entrance at the Main Street direct on-ramp followed by the diverge between the I-5 northbound and SR-57 northbound HOV lanes. Since the HCM requires two through lanes for analysis purposes, it is not possible to assess their operations using the standard weave and ramp junction methodologies. Instead, conditions were evaluated at these locations as part of the HOV lane assessment, using the V/C ratio at the HOV lane within the weave area (locations #7 and #8 in the southbound direction and location #4 in the northbound direction).

3.4 EXISTING INTERSECTION OPERATIONS

A level of service (LOS) analysis was conducted to evaluate existing intersection operating conditions during the weekday AM and PM peak hours. Table 3-6 summarizes the existing level of service at the study area intersections. Level of service calculation worksheets are included in Appendix F.

As shown in Table 3-6, all study area intersections operate acceptably (LOS D or better) under Existing conditions, with the exception of the following intersection:

- SR-55 SB Ramps/Fourth Street: LOS F in the AM peak hour. At this location, the poor operating conditions are due to the high volume of traffic destined to the SR-55 southbound on-ramp, which results in queued conditions along both eastbound and westbound Fourth Street (in particular, the westbound left-turns exceed the capacity of the provided turn pocket).

Table 3-6: Intersection LOS Summary – Existing (2011) Conditions – All Alternative Analysis Locations

ID	Intersection	Existing Conditions			
		AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS
1	Main / La Veta	20.1	C	27.1	C
2	Main / Memory	17.1	B	21.7	C
3	Main / Edgewood / I-5	42.6	D	49.0	D
4	Broadway / Santa Clara	32.7	C	27.2	C
5	Main / Santa Clara / I-5	45.3	D	52.3	D
6	Main / 17th	43.8	D	52.4	D
7	Penn / 17th	10.8	A	13.8	B
8	Santiago / 17th	32.8	C	36.3	D
9	Penn / I-5 SB Ramp	24.3	C	23.1	C
10	Main / 4th	11.3	B	12.0	B
11	Grand / 4th	33.6	C	42.2	D
12	I-5 SB Ramp / 4th	11.6	B	15.2	B
13	I-5 NB Ramp / 4th	8.9	A	18.2	B
14	Cabrillo / 4th	27.7	C	31.7	C
15	Tustin / 4th	29.9	C	38.2	D
16	Main / 1st	40.9	D	37.0	D
17	Grand / 1st	36.1	D	40.7	D
18	I-5 SB Ramp / 1st	8.3	A	10.4	B
19	Cabrillo / 1st	25.7	C	25.8	C
20	Tustin / 1st	15.5	B	16.5	B
21	I-5 Ramp / Santa Ana	19.9	B	51.4	D
22	Grand / Santa Ana	27.6	C	35.1	D
24	Mabury / Elk / 1st	28.6	C	39.5	D
25	Lyon / 1st	19.2	B	17.5	B
26	Cabrillo / State Fund	4.2	A	5.9	A
27	Cabrillo / Xerox Center	4.4	A	8.1	A
28	Golden Circle / 4th	7.9	A	10.2	B
29	Golden Circle / 1st	7.5	A	7.5	A
30	SR-55 SB Ramps / 4th	**>80.0**	**F**	19.9	B
31	SR-55 NB Ramps / 4th	19.1	B	36.8	D

Source: AECOM, 2012

Notes: **Bold** indicates intersection operating at unacceptable LOS.

[1] Delay is shown in seconds per vehicle. For signalized locations, delay reported is average delay of all approaches.

3.5 EXISTING OFF-RAMP QUEUING

A ramp queuing analysis was conducted to evaluate weekday AM and PM peak hour queues at key off-ramps in the study area (queues that would form at the controlling intersections). Table 3-7 summarizes the Existing (2011) queues at ramps in the study area most likely to be affected by the design alternatives. Queuing report worksheets are included in Appendix G. Under Existing conditions, all queues that form at the controlling intersection can be accommodated within available off-ramp queue space and not spill back to the mainline.

Table 3-7: Ramp Queue Summary – Existing (2011) Conditions – All Alternative Analysis Locations

ID	Off-Ramp Location	Controlling Intersection Approach	Available Storage Length (feet)	Percentile	AM Queue Length (feet)	PM Queue Length (feet)
3	Main / Edgewood / I-5	Northwest	1,357	50th	457	164
				95th	681	269
3	Main / Edgewood / I-5 (HOV off-ramp)	Eastbound	1,353	50th	16	15
				95th	96	73
5	Main / Santa Clara / I-5	Southeast	1,060	50th	306	253
				95th	554	448
12	I-5 SB Ramp / 4th	Southbound	1,000	50th	90	115
				95th	196	185
13	I-5 NB Ramp / 4th	Northbound	1,080	50th	38	105
				95th	144	228
22	Grand / Santa Ana (HOV off-ramp)	Westbound	1,538	50th	102	76
				95th	148	119
24	Mabury / Elk / 1st (I-5 Northbound (Loop ramp)	Southbound	1,280	50th	244	180
				95th	453	431

Source: AECOM, 2012.

3.6 EXISTING ACCIDENT DATA/SAFETY ANALYSIS

A summary of accident rates for the project area is provided in Table 3-8 below with a comparison to the statewide average. These data, which are for the 36-month period of July 1, 2007 through June 30 2010, indicate that multiple segments of the I-5 northbound freeway mainline within the study area have a higher accident rate than the statewide average. The following location experienced one fatal accident within the 36-month period:

- PM 31.627 (near Santa Ana Boulevard/Grand Avenue)

There are a total of 37 on- and off-ramps within the study area. Of these ramps, 18 have an accident rate greater than the statewide average in at least one of the three categories. The following three ramp locations experienced a fatal accident within the thirty-six month period:

- PM 31.627 (I-5 NB Off Ramp to Grand Avenue)
- PM 32.321 (I-5 SB On Ramp from Penn Way)
- PM 33.680 (I-5 NB Off Ramp to westbound SR-22/La Veta/Bristol)

Caltrans accident data are included in Appendix H.

Table 3-8: Accident Rate Summary - July 1, 2007 through June 30, 2010

Post Mile	Description	MVM or MV[1]	Segment Accident Rates			Statewide Average Rates		
			Fatal Accidents	Fatal + Injury	Total Accidents	Fatal Accidents	Fatal + Injury	Total Accidents
Northbound I-5 Mainline								
30.000 - 34.000	SR-55 to SR -57	782.86	0.000	0.31	**1.30**	0.012	0.35	1.21
Southbound I-5 Mainline								
30.000 - 34.000	SR-55 to SR -57	782.86	0.001	0.25	1.06	0.012	0.35	1.21
Northbound I-5 Ramps								
30.185	NB Off to SR-55/4th St	32.88	0.000	**0.27**	**0.79**	0.002	0.09	0.30
30.016	NB Off to 4th St	4.93	0.000	0.00	0.41	0.005	0.15	0.45
30.323	NB Off to SB SR-55	26.94	0.000	0.04	0.37	0.004	0.21	0.75
30.927	NB Off to 1st/4th St	13.93	0.000	0.00	0.07	0.002	0.09	0.30
31.023	NB Off to 4th St	7.67	0.000	**0.52**	1.04	0.004	0.42	1.20
31.024	NB Off to 1st St	8.77	0.000	0.00	0.23	0.002	0.36	1.10
31.194	NB On from 4th St	8.98	0.000	0.22	0.33	0.002	0.26	0.75
31.310	NB On HOV Connector from NB SR55	2.19	0.000	0.00	**0.46**	0.004	0.15	0.45
31.571	NB HOV Off to Grand Ave	2.58	0.000	0.39	0.39	0.004	0.42	1.20
31.627	NB Off to Grand Ave	7.89	**0.127**	**0.63**	0.89	0.004	0.42	1.20
31.778	NB On from Grand Ave	10.84	0.000	0.18	0.55	0.002	0.26	0.80
32.276	NB Off to 17th St	8.70	0.000	0.00	0.58	0.004	0.28	0.95
32.502	NB On from EB 17th St	5.74	0.000	0.00	0.35	0.004	0.20	0.70
32.556	NB On from WB 17th St	5.55	0.000	0.00	0.36	0.003	0.20	0.65
32.952	NB Off to NB Main/ Broadway	9.28	0.000	0.00	0.11	0.002	0.09	0.30
33.047	NB Off to NB Main St	5.62	0.000	**0.36**	0.53	0.004	0.26	0.85
33.048	NB Off to NB Broadway	6.69	0.000	0.15	0.30	0.004	0.26	0.85
33.210	NB On from Main/ Santa Clara	17.49	0.000	**0.17**	0.51	0.002	0.16	0.55
33.307	NB HOV On from Main/ Edgewood	2.58	0.000	**0.39**	**1.94**	0.002	0.16	0.55
33.680	NB Off to WB SR22/La Veta/ Bristol	24.69	**0.041**	0.16	**0.89**	0.005	0.20	0.60
Southbound I-5 Ramps								
30.261	SB Off to Newport Ave	8.99	0.000	0.00	0.22	0.005	0.15	0.45
30.403	SB Off to SB SR55	62.30	0.000	0.14	**0.59**	0.005	0.15	0.45

Post Mile	Description	MVM or MV[1]	Segment Accident Rates			Statewide Average Rates		
			Fatal Accidents	Fatal + Injury	Total Accidents	Fatal Accidents	Fatal + Injury	Total Accidents
30.828	SB On from 1st St	15.12	0.000	0.26	**0.79**	0.002	0.26	0.75
31.246	SB Off to 4th St	13.28	0.000	0.00	0.53	0.004	0.42	1.20
31.311	SB Off HOV Connector to SB SR55	2.19	0.000	**2.74**	**4.56**	0.005	0.20	0.60
31.549	SB HOV On from Grand Ave	1.92	0.000	0.52	**1.04**	0.002	0.26	0.75
31.847	SB On from Santa Ana Blvd	6.64	0.000	0.00	0.00	0.002	0.16	0.55
31.985	SB Off to Santa Ana Blvd	11.47	0.000	0.00	0.17	0.004	0.28	0.95
32.321	SB On from Penn Way	8.05	**0.124**	**0.25**	**1.12**	0.002	0.16	0.55
32.490	SB off to Penn Way	11.65	0.000	0.00	0.17	0.004	0.28	0.95
32.868	SB On from Main St	10.14	0.000	0.10	**0.59**	0.002	0.16	0.55
33.207	SB Off to SB Main St/Santa Clara	5.68	0.000	0.18	**0.88**	0.004	0.26	0.85
33.225	SB On from EB SR22/SB SR-57	74.25	0.000	0.03	0.04	0.002	0.06	0.20
33.312	SB Off HOV to Main/ Edgewood	1.43	0.000	**2.81**	**4.91**	0.004	0.28	0.95
33.328	SB Off to SB Broadway	11.13	0.000	0.09	0.72	0.004	0.26	0.85
33.681	SB/NB Off La Veta/Bristol	11.66	0.000	**0.26**	**0.52**	0.002	0.09	0.30
33.760	SB Off at Main/ Broadway	9.43	0.000	**0.32**	**2.33**	0.001	0.07	0.25

Source: Caltrans TASAS and Accident Data
Bold = exceeds statewide average for similar facilities
MVM = Million Vehicle Miles
MV = Million Vehicles
Accident rates are expressed as # accidents/MVM[1]
[1] For mainline segments, MVM is used for accident rates. For ramps, MV is used.

Accident data at the HOV ramps at Main Street include collisions that occurred during the 36-month period from January 1, 2008 to December 31, 2010 on I-5 from PM 30.0 to 34.5.

According to TASAS Table 3-8, accident rates along the northbound mainline are higher than the statewide average collision rates, while the southbound direction has lower accident rates. There were approximately 1,023 reported collisions in the northbound direction, of which 72 (7 percent) collisions took place in the HOV lane or the buffer area. Of the collisions in the HOV lane, a majority of them were the rear-end type that took place during the PM peak hour. Observation of the southbound direction showed similar results. Of the 851 reported collisions, approximately 39 collisions (or 4.6 percent) took place in either the HOV lane or the buffer area, with the majority of collisions classified as the rear-end type.

Evaluation of the accident data revealed the correlation between traffic congestion and collisions (most rear-end collisions occur during peak hour congested conditions). The proposed HOV lane addition would increase capacity and reduce congestion; thereby reducing the potential for rear end type collisions.

Evaluation of the collision rates at the HOV ramps at Main Street shown in Table 3-8 show that the study area ramp locations have significantly higher than statewide average collision rates. These ramps have low traffic demand and could be removed with negligible impact. Alternatives 2B and 5B propose the removal of these ramps, which would improve safety. The freeway mainline would also benefit from additional clear recovery space available in the median.

4.0 HOV LANE ALTERNATIVE ANALYSIS

This section discusses effects of the proposed HOV Lane Alternatives (Alternatives 2A, 2B, 5A, and 5B) in the study area.

4.1 OPENING YEAR (2018) NO BUILD

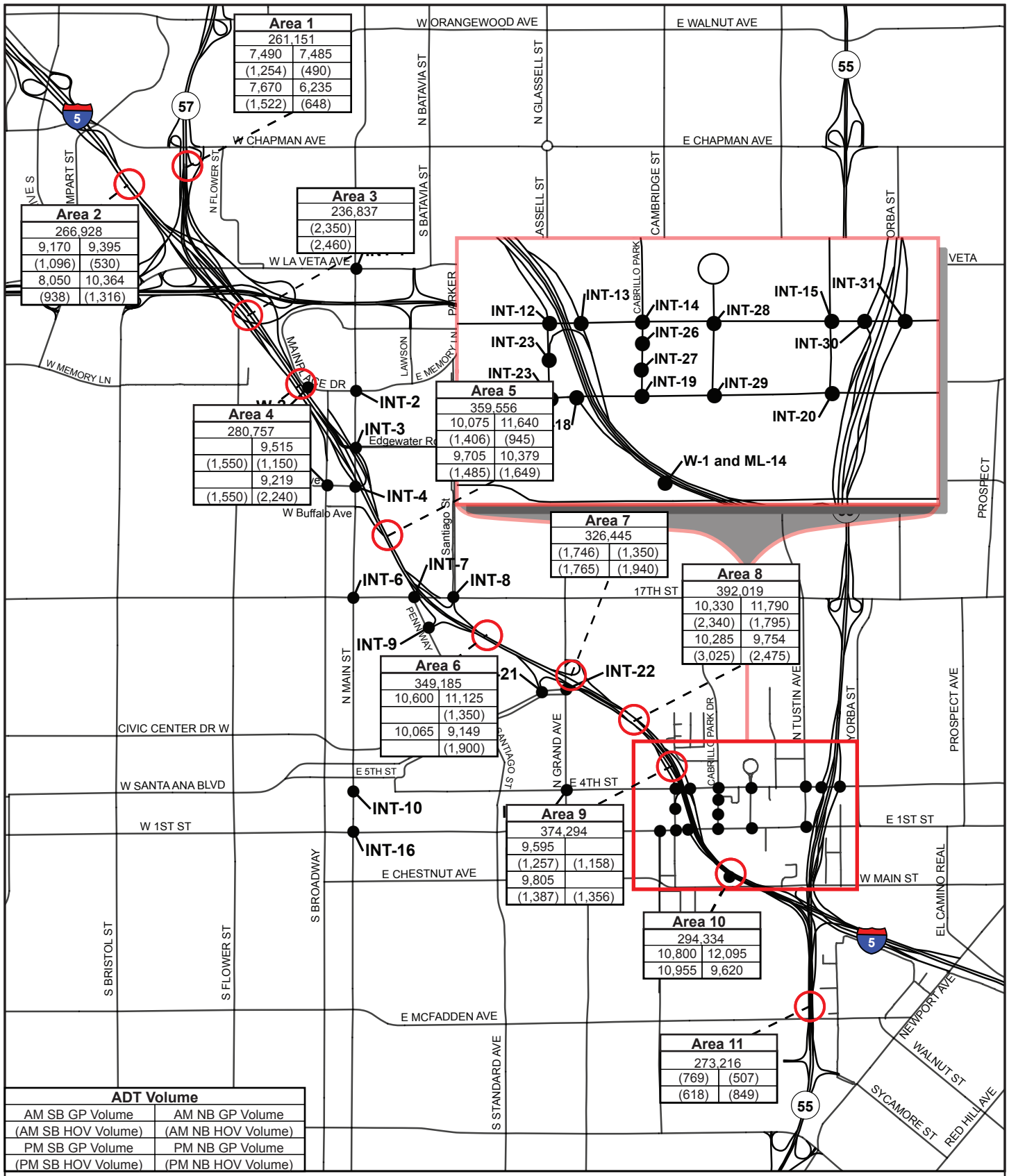
4.1.1 FREEWAY MAINLINE PERFORMANCE

Table 4-1 shows the mainline LOS analysis for Opening Year (2018) No Build conditions. Figure 9 displays the mainline volumes at each of the study area location. As shown in Table 4-1, during the weekday AM peak hour, 9 of the 12 analysis segments on the I-5 Freeway are forecast to operate at LOS E/F; 10 of the 12 analysis segments on the I-5 Freeway are forecast to operate at LOS E/F during PM peak hour. HCS worksheets can be found in Appendix C.

Table 4-1: Freeway Mainline LOS Summary – Opening Year (2018) Conditions – No Build

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			GP	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
1	SR-57 between Chapman off-ramp and SR-22 off-ramp	SB	3	0	**7,490**	**>45.0**	**F**	**7,670**	**>45.0**	**F**
2	I-5 between Chapman on-ramp and SR-22 off-ramp	SB	5	2	9,170	32.2	D	8,050	27.2	D
5	I-5 between Main on-ramp and 17th/Penn off-ramp	SB	5	1	**10,075**	**38.0**	**E**	**9,705**	**35.4**	**E**
6	I-5 between 17th on-ramp and Santa Ana off-ramp	SB	5	1	**10,600**	**42.6**	**E**	**10,065**	**38.0**	**E**
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**10,330**	**40.1**	**E**	**10,285**	**39.7**	**E**
9	I-5 between Fourth off-ramp and First Street on-ramp	SB	5	1	9,595	34.7	D	**9,805**	**36.1**	**E**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**11,790**	**>45.0**	**F**	**9,754**	**35.7**	**E**
6	I-5 between Grand Ave on-ramp and 17th off-ramp	NB	5	1	**11,125**	**>45.0**	**F**	9,149	32.1	D
5	I-5 between 17th on-ramp and Main/Broadway off-ramp	NB	5	1	**11,640**	**>45.0**	**F**	**10,379**	**40.5**	**E**
4	I-5 between Main on-ramp and SR-22 exit	NB	4	1	**9,515**	**>45.0**	**F**	**9,219**	**>45.0**	**F**
2	I-5 between SR-22 on-ramp and Chapman off-ramp	NB	5	1	9,395	33.5	D	**10,364**	**40.4**	**E**
1	SR-57 between Chapman off-ramp and Chapman on-ramp	NB	3	0	**7,485**	**>45.0**	**F**	**6,235**	**41.2**	**E**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)



I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED

Figure 9 - I-5 Freeway Volumes – 2018 No Build Conditions

4.1.2 HOV LANE PERFORMANCE

Freeway HOV volumes are shown in Figure 9, and the HOV analysis results are summarized in Table 4-2. Forecast weekday AM and PM peak hour HOV volumes by direction and measures of effectiveness are included in Table 4-2. As shown, two analysis HOV lane segments would operate at LOS E or F during the AM peak hour and five analysis HOV lane segments would operate at LOS E or F during the PM peak hour, similar to conditions under Existing conditions. In addition, there are several HOV lane segments that have volumes higher than the Caltrans' recommended volume of 1,600 vphpl for one-lane segments and 1,750 vphpl (3,500 vph total) for two-lane segments.

As noted previously, there is a severe bottleneck where the HOV lane from I-5 southbound connects with the HOV lane from SR-57 southbound, with a capacity limit of 1,550 vph. North of this bottleneck, there is substantial congestion on both the I-5 southbound and SR-57 southbound HOV lanes, which would be worsened under Opening Year (2018) Conditions. During both weekday AM and PM peak hours, there would be an un-served demand of about 800 and 910 vehicles, respectively, and both time periods would operate at LOS F conditions. However, since this bottleneck restricts downstream volumes, analysis locations to the south tend to operate under capacity.

Similarly, there is a bottleneck where the HOV lane from I-5 northbound merges with the HOV lane from SR-55 northbound, with a capacity limit of 1,900 vph (also identified through a review of Caltrans PeMS data) – note that this merge is located to the north of the Grand Avenue HOV direct exit ramp. At this location, there would be an un-served demand of about 40 vehicles in the weekday PM peak hour, resulting in minor delays to traffic flows along the I-5 HOV lane, and LOS F conditions. However, since this bottleneck restricts downstream volumes, analysis locations to the north tend to operate under capacity. HOV lane calculations can be seen in Appendix D.

Table 4-2: HOV LOS Summary – Opening Year (2018) Conditions – No Build

Map Ref #	Location		# of Lanes	AM Peak Hour			PM Peak Hour		
				Vol.	Capacity (V/C)	LOS	Vol.	Capacity (V/C)	LOS
1	SR-57 north of I-5 HOV merge	SB	1	1,254	0.66	C	1,522	0.80	D
2	I-5 north of SR-57 HOV merge	SB	1	1,096	0.58	C	938	0.49	B
3	I-5 at SR-57 HOV merge	SB	1	***2,350***	***1.24***	***F***	***2,460***	***1.29***	***F***
4	I-5 between SR-57 HOV merge and Main HOV off-ramp[1]	SB	1	1,550	0.82	D	1,550	0.82	D
5	I-5 between Main HOV off-ramp and HOV entrance south of Lincoln overcrossing	SB	1	1,406	0.74	D	1,485	0.78	D
7	I-5 between HOV entrance and Grand HOV on-ramp	SB	1	***1,746***	***0.92***	***E***	***1,765***	***0.93***	***E***
8	I-5 between Grand HOV on-ramp and SR-55 HOV diverge	SB	2	2,026	0.53	C	2,005	0.53	C
9	I-5 south of SR-55 HOV diverge	SB	1	1,257	0.66	C	1,387	0.73	D
11	SR-55 south of I-5 HOV diverge	SB	1	769	0.40	B	618	0.33	B
11	SR-55 south of I-5 HOV merge	NB	1	507	0.27	A	849	0.45	B
9	I-5 south of SR-55 HOV merge	NB	1	1,158	0.61	C	1,356	0.71	D

Map Ref #	Location		# of Lanes	AM Peak Hour			PM Peak Hour		
				Vol.	Capacity (V/C)	LOS	Vol.	Capacity (V/C)	LOS
8	I-5 between SR-55 HOV merge and Grand HOV off-ramp	NB	2	1,665	0.44	B	2,205	0.58	C
7	I-5 at HOV lane merge (2 to 1 lane)	NB	1	1,350	0.71	D	***1,940***	***1.02***	***F***
6	I-5 between HOV lane merge and HOV lane exit north of Lincoln overcrossing	NB	1	1,350	0.71	D	***1,900***	***1.00***	***F***
5	I-5 between HOV exit and Main HOV off-ramp	NB	1	965	0.51	C	*1,649*	*0.87*	*D*
4	I-5 between Main HOV on-ramp and SR-57 diverge	NB	1	1,020	0.54	C	***1,964***	***1.03***	***F***
2	I-5 north of SR-57 diverge	NB	1	530	0.28	A	1,316	0.69	C
1	SR-57 north of I-5 HOV diverge	NB	1	490	0.26	A	648	0.34	B

Source: AECOM, 2012.
Notes: **Bold** indicates HOV segment operating at LOS E/F. *Italics* indicate locations where the HOV lane has greater than 1,600 vphpl for 1-lane segment; 1,750 vphpl for 2-lane segment.
[1] Bottleneck location which constrains downstream volumes.

4.1.3 WEAVING PERFORMANCE

Under Opening Year (2018) No Build conditions, the weaving section on the I-5 Freeway northbound between the Main Street on-ramp and the SR-22 exit would operate at LOS E during both the weekday AM and PM peak hours, as shown in Table 4-3, with an increase in density and weaving segment V/C ratio over Existing conditions due to the general increase in volumes in the area. Weaving calculations can be seen in Appendix E.

Table 4-3: HCM Weaving LOS Summary – Opening Year (2018) Conditions – No Build

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**38.9**	**E**	**0.89**	**41.9**	**E**	**0.92**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

A second methodology using the Highway Design Manual (HDM), as previously described, was utilized to analyze the weaving section and is shown in Table 4-4. Based on HDM, the weaving section operates at LOS F conditions during both the weekday AM and PM peak hours. Weaving calculations using the HDM methodology are included in Appendix E.

Table 4-4: HDM Weaving LOS Summary – Opening Year (2018) Conditions – No Build

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

4.1.4 INTERSECTION OPERATIONS

A level of service analysis was conducted to evaluate Opening Year (2018) No Build intersection operating conditions during the weekday AM and PM peak hours. Table 4-5 summarizes the Opening Year (2018) No Build level of service at the study area intersections. Traffic volumes for Opening Year (2018) are included in Appendix B. Level of service calculation worksheets are included in Appendix F.

As shown in Table 4-5, all study area intersections would operate acceptably (LOS D or better) under Opening Year (2018) No Build conditions.

Table 4-5: Intersection LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternatives – No Build

ID	Intersections	AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS
1	Main / La Veta	20.0	B	26.4	C
2	Main / Memory	17.1	B	21.4	C
3	Main / Edgewood / I-5	40.3	D	48.5	D
4	Broadway / Santa Clara	30.6	C	28.2	C
5	Main / Santa Clara / I-5	42.8	D	51.6	D
6	Main / 17th	42.6	D	49.5	D
7	Penn / 17th	10.8	B	13.6	B
8	Santiago / 17th	32.6	C	35.5	D
9	Penn / I-5 SB Ramp	24.4	C	23.1	C

Source: AECOM, 2012
Notes:

Bold indicates intersection operating at unacceptable LOS.

[1] Delay is shown in seconds per vehicle. For signalized locations, delay reported is average delay of all approaches.

4.1.5 RAMP QUEUING

The queuing analysis results of the Opening Year (2018) No Build scenarios for the weekday AM and PM peak hours are presented in Table 4-6. Queue length calculations can be found in Appendix G. As with Existing conditions, queues that would develop

under the Opening Year (2018) No Build scenario could be accommodated within the available storage distance and not affect freeway operations.

Table 4-6: Ramp Queue Summary – Opening Year (2018) Conditions – No Build

#	Off-Ramp Location	Controlling Intersection Approach	Available Storage Length (feet)	Percentile	AM Queue Length (feet)	PM Queue Length (feet)
3	Main / Edgewood / I-5	Northwest	1,357	50th	432	161
				95th	664	264
3	Main / Edgewood / I-5 (HOV off-ramp)	Eastbound	1,353	50th	20	17
				95th	110	82
5	Main / Santa Clara / I-5	Southeast	1,060	50th	290	268
				95th	535	460
22	Grand / Santa Ana (HOV off-ramp)	Westbound	1,538	50th	102	78
				95th	149	122

Source: AECOM, 2012.
Notes: **Bold** = queue length exceeding available capacity
EB = Eastbound WB = Westbound

4.2 OPENING YEAR (2018) HOV LANE ALTERNATIVES 2A AND 2B

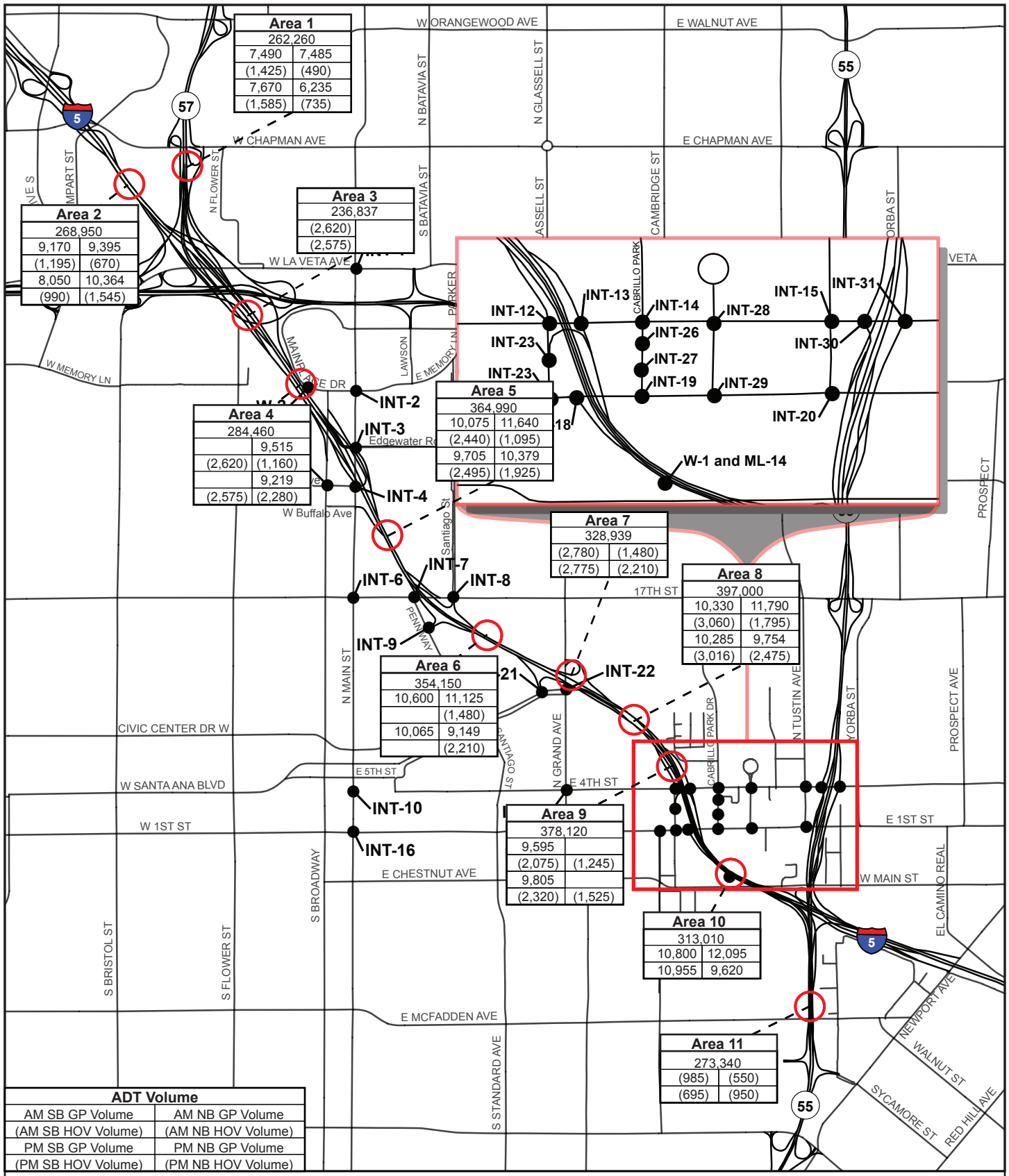
This section shows the Opening Year (2018) forecast traffic operating conditions under HOV Lane Alternatives 2A and 2B. For both alternatives, a second continuous HOV lane would be added within the project limits, with barriers located, when needed, between the first and second HOV lanes. Additionally, HOV Lane Alternative 2B includes the elimination of the Main Street direct I-5 HOV entrance and exit ramps. With the exception of the Main Street HOV ramp elimination, all configurations and conditions would be the same between Alternative 2A and Alternative 2B.

4.2.1 FREEWAY MAINLINE PERFORMANCE

Table 4-7 and Table 4-8 show the mainline LOS analysis for Opening Year (2018) HOV Lane Alternatives 2A and 2B. Figure 10 displays HOV Lane Alternative 2A mainline volumes, and Figure 11 displays HOV Lane Alternative 2B mainline volumes at each of the study area location.

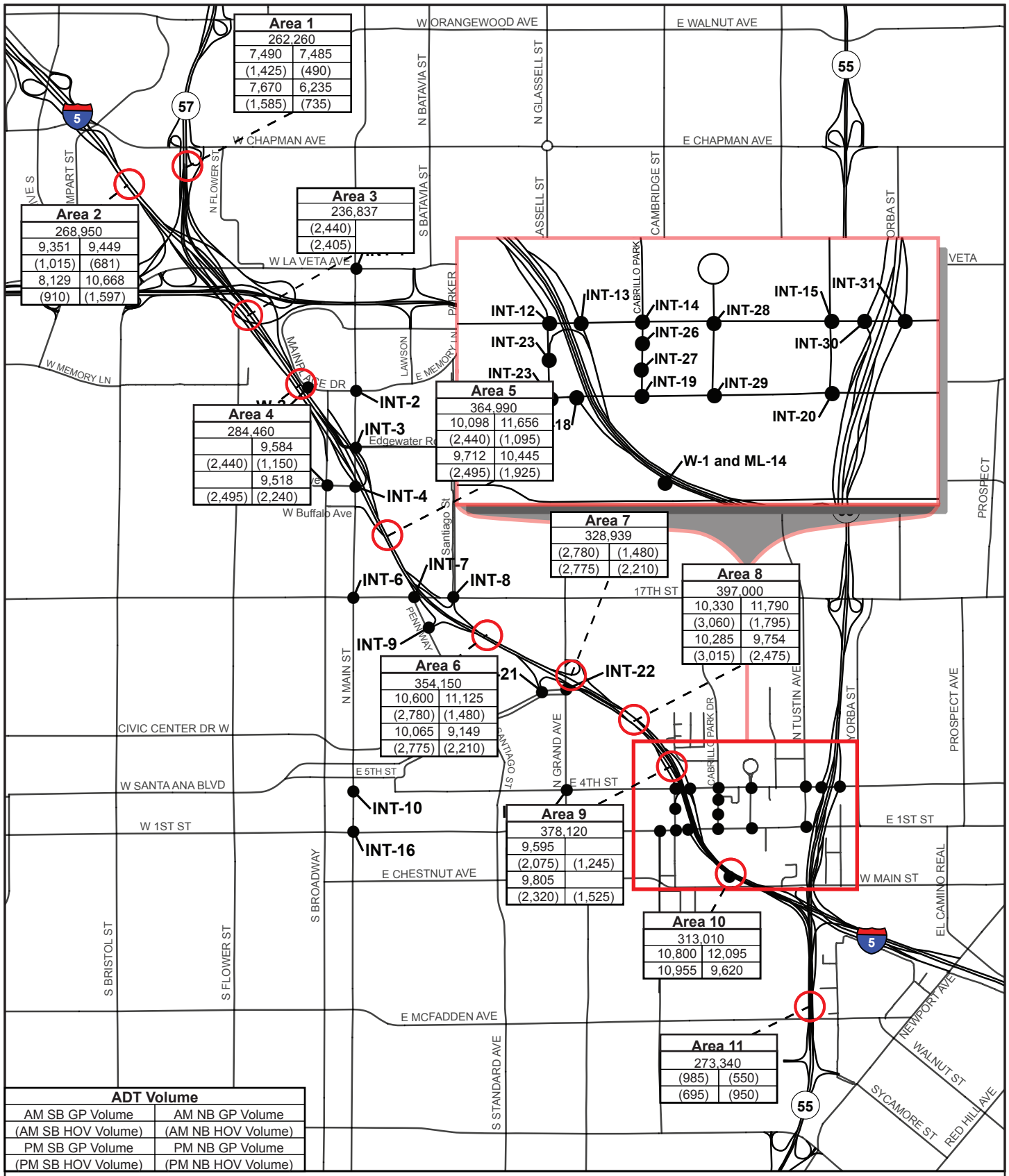
For the freeway mainline, HOV Lane Alternative 2A is not forecast to have an appreciable effect on traffic volumes as discussed in the Section 2.3 Volume Development. Therefore, freeway mainline conditions under HOV Lane Alternative 2A results would be the same as with No Build, as shown in Table 4-6.

For HOV Lane Alternative 2B, both the direct HOV ramps at Main Street would be eliminated, thereby requiring users of these ramps to relocate to other general purpose ramps in the area. As a result, there would be changes in the freeway access patterns and thus minor differences in freeway mainline volumes, as shown in Table 4-7. HCS development worksheets can be found in Appendix C.



I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED

Figure 10 – I-5 Freeway Volumes – 2018 2A



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I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED

Figure 11 – I-5 Freeway Volumes – 2018 2B

During Opening Year (2018), 9 of the 12 analysis segments on the I-5 Freeway are forecast to operate at LOS E or F during the weekday AM peak hour; 10 of the 12 segments are forecasted to operate at LOS E or F during the weekday PM peak hour, as shown in Table 4-7.

Table 4-7: Freeway Mainline LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternative 2A

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			GP	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
1	SR-57 between Chapman off-ramp and SR-22 off-ramp	SB	3	0	**7,490**	**>45.0**	**F**	**7,670**	**>45.0**	**F**
2	I-5 between Chapman on-ramp and SR-22 off-ramp	SB	5	2	9,170	32.2	D	8,050	27.2	D
5	I-5 between Main on-ramp and 17th/Penn off-ramp	SB	5	1	**10,075**	**38.0**	**E**	**9,705**	**35.4**	**E**
6	I-5 between 17th on-ramp and Santa Ana off-ramp	SB	5	1	**10,600**	**42.6**	**E**	**10,065**	**38.0**	**E**
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**10,330**	**40.1**	**E**	**10,285**	**39.7**	**E**
9	I-5 between Fourth off-ramp and First Street on-ramp	SB	5	1	9,595	34.7	D	**9,805**	**36.1**	**E**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**11,790**	**>45.0**	**F**	**9,754**	**35.7**	**E**
6	I-5 between Grand Ave on-ramp and 17th off-ramp	NB	5	1	**11,125**	**>45.0**	**F**	9,149	32.1	D
5	I-5 between 17th on-ramp and Main/Broadway off-ramp	NB	5	1	**11,640**	**>45.0**	**F**	**10,379**	**40.5**	**E**
4	I-5 between Main on-ramp and SR-22 exit	NB	4	1	**9,515**	**>45.0**	**F**	**9,219**	**>45.0**	**F**
2	I-5 between SR-22 on-ramp and Chapman off-ramp	NB	5	1	9,395	33.5	D	**10,364**	**40.4**	**E**
1	SR-57 between Chapman off-ramp and Chapman on-ramp	NB	3	0	**7,485**	**>45.0**	**F**	**6,235**	**41.2**	**E**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

Table 4-8: Freeway Mainline LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternative 2B

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			GP	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
1	SR-57 between Chapman off-ramp and SR-22 off-ramp	SB	3	0	**7,490**	**>45.0**	**F**	**7,670**	**>45.0**	**F**
2	I-5 between Chapman on-ramp and SR-22 off-ramp	SB	5	2	9,351	33.3	D	8,129	27.8	D
5	I-5 between Main on-ramp and 17th/Penn off-ramp	SB	5	1	**10,098**	**38.2**	**E**	**9,712**	**35.5**	**E**
6	I-5 between 17th on-ramp and Santa Ana off-ramp	SB	5	1	**10,600**	**42.6**	**E**	**10,065**	**38.0**	**E**
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**10,330**	**40.1**	**E**	**10,285**	**39.7**	**E**
9	I-5 between Fourth off-ramp and First Street on-ramp	SB	5	1	9,595	34.7	D	**9,805**	**36.1**	**E**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**11,790**	**>45.0**	**F**	**9,754**	**35.7**	**E**
6	I-5 between Grand Ave on-ramp and 17th off-ramp	NB	5	1	**11,125**	**>45.0**	**F**	9,149	32.1	D
5	I-5 between 17th on-ramp and Main/Broadway off-ramp	NB	5	1	**11,656**	**>45.0**	**F**	**10,445**	**41.1**	**E**
4	I-5 between Main on-ramp and SR-22 exit	NB	4	1	**9,584**	**>45.0**	**F**	**9,518**	**>45.0**	**F**
2	I-5 between SR-22 on-ramp and Chapman off-ramp	NB	5	1	9,449	33.8	D	**10,668**	**43.2**	**E**
1	SR-57 between Chapman off-ramp and Chapman on-ramp	NB	3	0	**7,485**	**>45.0**	**F**	**6,235**	**41.2**	**E**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

4.2.2 HOV LANE PERFORMANCE

HOV lane analysis results for the HOV Lane Alternatives 2A and 2B are summarized in Table 4-9 and Table 4-10. With the addition of the second HOV lane between SR-55 and SR-57, the number of vehicles able to use the HOV lanes would increase due to the elimination of the northbound and southbound bottleneck locations (the lane reductions at the I-5 southbound / SR-57 southbound connection and at the I-5 northbound / SR-55 northbound connection would be eliminated). For both alternatives, operating conditions would improve above No Build at locations where the second lane was added, and there would be substantial increases in throughput in both directions (up to 1,070 vph in the weekday AM peak hour and 1,025 vph in the weekday PM peak hour for Alternative 2A, and up to 1,030 vph in the weekday AM peak hour and 1,010 vph in the weekday PM peak hour for Alternative 2B). At the northern end of the study area, HOV lane volumes

for Alternative 2B would be slightly less than for Alternative 2A due to the elimination of the direct HOV entrance and exit ramps at Main Street.

With the HOV Lane Alternatives, there is also projected to be an additional HOV demand over and above the No Build demand – additional vehicles would be attracted to the HOV facility due to its additional capacity and the elimination of the bottlenecks (400 vph in the weekday AM peak hour and 385 vph in the weekday PM peak hour).

Overall, under the Year 2018 conditions, all analysis locations would operate at LOS D or better, with the exception of the southbound I-5 HOV lane directly south of the SR-55 exit. In this location, the additional throughput that would be allowed in the HOV lanes with the project and would continue south along I-5 could not be accommodated in the single HOV lane after the SR-55 split. As a result, the HOV lane would be over-capacity under both HOV Lane Alternatives, leading to LOS F conditions and minor congestion, which would result in some delays to HOV users.

HOV lane calculations are provided in Appendix D.

Table 4-9: HOV LOS Summary – Opening Year (2018) Conditions - HOV Lane Alternative 2A

Map Ref #	Location		# of Lanes	AM Peak Hour			PM Peak Hour		
				Vol.	Capacity (V/C)	LOS	Vol.	Capacity (V/C)	LOS
1	SR-57 north of I-5 HOV merge	SB	1	1,425	0.75	D	1,585	0.83	D
2	I-5 north of SR-57 HOV merge	SB	1	1,195	0.63	C	990	0.52	C
3	I-5 at SR-57 HOV merge	SB	2	2,620	0.69	C	2,575	0.68	C
4	I-5 between SR-57 HOV merge and Main HOV off-ramp	SB	2	2,620	0.69	C	2,575	0.68	C
5	I-5 between Main HOV off-ramp and HOV entrance south of Lincoln overcrossing	SB	2	2,440	0.64	C	2,495	0.66	C
7	I-5 between HOV entrance and Grand HOV on-ramp	SB	2	2,780	0.73	D	2,775	0.73	D
8	I-5 between Grand HOV on-ramp and SR-55 HOV diverge	SB	2	3,060	0.81	D	3,015	0.79	D
9	I-5 south of SR-55 HOV diverge	SB	1	***2,075***	***1.09***	***F***	***2,320***	***1.22***	***F***
11	SR-55 south of I-5 HOV diverge	SB	1	985	0.52	C	695	0.37	B
11	SR-55 south of I-5 HOV merge	NB	1	550	0.29	A	950	0.50	C
9	I-5 south of SR-55 HOV merge	NB	1	1,245	0.66	C	1,525	0.80	D
8	I-5 between SR-55 HOV merge and Grand HOV off-ramp	NB	2	1,795	0.47	B	2,475	0.65	C
7	I-5 at HOV lane merge (2 to 1 lane)	NB	2	1,480	0.39	B	2,210	0.58	C
6	I-5 between HOV lane merge and HOV lane exit north of Lincoln overcrossing	NB	2	1,480	0.39	B	2,210	0.58	C
5	I-5 between HOV exit and Main HOV off-ramp	NB	2	1,095	0.29	A	1,925	0.51	C
4	I-5 between Main HOV on-ramp and SR-57 diverge	NB	2	1,160	0.31	B	2,280	0.60	C
2	I-5 north of SR-57 diverge	NB	1	670	0.35	B	1,545	0.81	D
1	SR-57 north of I-5 HOV diverge	NB	1	490	0.26	A	735	0.39	B

Source: AECOM, 2012.
Notes: **Bold** indicates HOV segment operating at LOS E/F. *Italics* indicate locations where the HOV lane has greater than 1,600 vphpl for 1-lane segment; 1,750 vphpl for 2-lane segment.

Table 4-10: HOV LOS Summary – Opening Year (2018) Conditions - HOV Lane Alternative 2B

Map Ref #	Location		# of Lanes	AM Peak Hour			PM Peak Hour		
				Vol.	Capacity (V/C)	LOS	Vol.	Capacity (V/C)	LOS
1	SR-57 north of I-5 HOV merge	SB	1	1,425	0.75	D	1,585	0.83	D
2	I-5 north of SR-57 HOV merge	SB	1	1,015	0.53	C	910	0.48	B
3	I-5 at SR-57 HOV merge	SB	2	2,440	0.64	C	2,495	0.66	C
4	I-5 between SR-57 HOV merge and Main HOV off-ramp	SB	2	2,440	0.64	C	2,495	0.66	C
5	I-5 between Main HOV off-ramp and HOV entrance south of Lincoln overcrossing	SB	2	2,440	0.64	C	2,495	0.66	C
7	I-5 between HOV entrance and Grand HOV on-ramp	SB	2	2,780	0.73	D	2,775	0.73	D
8	I-5 between Grand HOV on-ramp and SR-55 HOV diverge	SB	2	3,060	0.81	D	3,015	0.79	D
9	I-5 south of SR-55 HOV diverge	SB	1	***2,075***	***1.09***	***F***	***2,320***	***1.22***	***F***
11	SR-55 south of I-5 HOV diverge	SB	1	985	0.52	C	695	0.37	B
11	SR-55 south of I-5 HOV merge	NB	1	550	0.29	A	950	0.50	C
9	I-5 south of SR-55 HOV merge	NB	1	1,245	0.66	C	1,525	0.80	D
8	I-5 between SR-55 HOV merge and Grand HOV off-ramp	NB	2	1,795	0.47	B	2,475	0.65	C
7	I-5 at HOV lane merge (2 to 1 lane)	NB	2	1,480	0.39	B	2,210	0.58	C
6	I-5 between HOV lane merge and HOV lane exit north of Lincoln overcrossing	NB	2	1,480	0.39	B	2,210	0.58	C
5	I-5 between HOV exit and Main HOV off-ramp	NB	2	1,095	0.29	A	1,925	0.51	C
4	I-5 between Main HOV on-ramp and SR-57 diverge	NB	2	1,150	0.30	B	2,240	0.59	C
2	I-5 north of SR-57 diverge	NB	1	681	0.36	B	1,597	0.84	D
1	SR-57 north of I-5 HOV diverge	NB	1	490	0.26	A	735	0.39	B

Source: AECOM, 2012.
Notes: **Bold** indicates HOV segment operating at LOS E/F. *Italics* indicate locations where the HOV lane has greater than 1,600 vphpl for 1-lane segment; 1,750 vphpl for 2-lane segment.

Alternatives 2A and 2B would introduce a new weaving segment when compared to Existing conditions and Alternatives 5A and 5B. The presence of a barrier in Alternatives 2A and 2B beginning south of the Lincoln Avenue overcrossing creates a new weave segment between HOV vehicles originating from the northbound SR-55 HOV connector and those destined to 17th Street, Main Street, or SR-22 via the northbound I-5 HOV lane. Based on a review of local trip destinations, it is anticipated that only a small portion of the 550 AM and 950 PM peak hour SR-55 HOV vehicles would weave to access the HOV lane exit. Given the distance available to exit (over 1,500 feet), it is anticipated that this weaving activity would not disrupt HOV lane operations. It should be noted that if HOV vehicles destined to 17th Street, Main Street, or SR-22 miss the exit at this location, the next available exit would not be until the SR-57 overcrossing.

4.2.3 WEAVING PERFORMANCE

With HOV Lane Alternative 2A, conditions at the I-5 Freeway weaving segment would be the same as with No Build, as there would be no change to freeway mainline or Main

Street on-ramp volumes with Alternative 2A, as illustrated in Tables 4-11 and 4-12. Weaving calculations can be seen in Appendix E.

Table 4-11: HCM Weaving LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternative 2A

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**38.9**	**E**	**0.89**	**41.9**	**E**	**0.92**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 4-12: HDM Weaving LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternative 2A

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

However, since Alternative 2B would eliminate the Main Street direct HOV on-ramp, there would be an increase in volumes along both the freeway mainline and at the Main Street general-purpose on-ramp. As a result, weaving conditions under Alternative 2B would be slightly worse during both the weekday AM and PM peak hours, as shown in Tables 4-13 and 4-14.

Table 4-13: HCM Weaving LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternative 2B

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
NB I-5 between Main on-ramp and SR-57 off-ramp	NB	1,650	**39.2**	**E**	**0.89**	**44.7**	**E**	**0.96**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 4-14: HDM Weaving LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternative 2B

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
NB I-5 between Main on-ramp and SR-57 off-ramp	NB	1,650	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

4.2.4 INTERSECTION OPERATIONS

A level of service analysis was conducted to evaluate Opening Year (2018) Alternatives 2A and 2B intersection operating conditions during the weekday AM and PM peak hours. Table 4-15 summarizes the Opening Year (2018) Alternative 2A and 2B level of service at the study area intersections. Traffic volumes for Opening Year (2018) Alternative 2A and 2B are included in Appendix B. Level of service calculation worksheets are included in Appendix F. With Alternative 2A, the increase in activity along the HOV lanes, due to the second HOV lane in each direction, would result in minor increases in intersection volumes at intersections near the Main Street direct HOV ramps. For Alternative 2B, with the closure of the Main Street I-5 HOV entrance and exit ramps, there would be a redistribution of vehicles in the study area, as high-occupant vehicles would need to find alternative ramps to travel to and from I-5 as discussed in Section 3.3. The redistribution of vehicles can found in Appendix B. For each affected local intersection, minor modifications to signal timing (no geometric changes) were applied where applicable to account for additional vehicles that were redistributed as part of the alternatives.

Table 4-15 reflects only the locations where the LOS changes from the No Build (i.e., does not include intersections affected by the Ramp Alternatives). Under both Alternatives 2A and 2B, all study intersections would continue to operate acceptably at LOS D or better.

Table 4-15: Intersection LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternatives 2A and 2B

ID	Intersection	2018 HOV Alt 2A Conditions				2018 HOV Alt 2B Conditions			
		AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS
1	Main / La Veta	19.8	B	26.4	C	19.8	B	26.4	C
2	Main / Memory	17.1	B	21.3	C	17.1	B	21.3	C
3	Main / Edgewood / I-5	40.4	D	52.3	D	36.5	D	40.5	D
4	Broadway / Santa Clara	30.2	C	28.1	C	30.2	C	28.1	C
5	Main / Santa Clara / I-5+	43.0	D	51.2	D	43.0	D	51.2	D
6	Main / 17th+	42.9	D	49.9	D	42.9	D	49.9	D
7	Penn / 17th	10.8	B	13.6	B	10.8	B	13.6	B
8	Santiago / 17th	32.6	C	35.5	D	32.6	C	35.5	D
9	Penn / I-5 SB Ramp	24.4	C	23.1	C	24.4	C	23.1	C

Source: AECOM, 2012

Notes:

+ Minor intersection signal timing adjustments made to account for additional vehicles that were redistributed as part of HOV Lane Alternatives 2A and 2B.

Bold indicates intersection operating at unacceptable LOS.

[1] Delay is shown in seconds per vehicle. For signalized locations, delay reported is average delay of all approaches.

4.2.5 RAMP QUEUING

The queuing analysis results of the Opening Year (2018) HOV Lane Alternatives 2A and 2B during the weekday AM and PM peak hours are presented in Table 4-16. As with No Build conditions, queues that would develop under the HOV Lane Alternatives 2A and 2B could be accommodated within the available storage distance. HOV Lane Alternative 2A would have queue lengths almost identical to No Build conditions. HOV Lane Alternative 2B would have increased queue lengths at the off-ramps due to more vehicles exiting at these locations with the elimination of the Main Street HOV ramps. Queue length calculations can be found in Appendix G.

Table 4-16: Ramp Queuing Summary – Opening Year (2018) Conditions – HOV Lane Alternatives 2A and 2B

#	Off-Ramp Location	Controlling Intersection Approach	Available Storage Length (feet)	Percentile	2018 2A		2018 2B	
					AM Queue Length (feet)	PM Queue Length (feet)	AM Queue Length (feet)	PM Queue Length (feet)
3	Main / Edgewood / I-5	Northwest	1,357	50th	432	161	432	161
				95th	664	264	664	266
3	Main / Edgewood / I-5 (HOV off-ramp)	Eastbound	1,353	50th	24	19	82	127
				95th	129	94	239	333
5	Main / Santa Clara / I-5	Southeast	1,060	50th	290	268	290	358
				95th	535	459	535	555
22	Grand / Santa Ana (HOV off-ramp)	Westbound	1,538	50th	102	78	102	86
				95th	149	122	149	131

Source: AECOM, 2012.

4.3 OPENING YEAR (2018) HOV LANE ALTERNATIVES 5A AND 5B

This section shows the Opening Year (2018) forecast traffic operating conditions under HOV Lane Alternatives 5A and 5B. For both alternatives, a second continuous-access HOV lane would be added within the project limits, with barriers in select locations between the HOV lanes and the mainline. Additionally, HOV Lane Alternative 5B includes the closure of the Main Street direct I-5 HOV entrance and exit ramps. With the exception of the Main Street HOV ramp elimination, all configurations and conditions would be the same between Alternative 5A and Alternative 5B.

4.3.1 FREEWAY MAINLINE PERFORMANCE

For the freeway mainline, HOV Lane Alternative 5A is not forecast to have an appreciable effect on traffic volumes compared to Alternative 2A, as discussed in the Section 2.3 Volume Development. Figure 12 displays the HOV Lane Alternative 5A mainline volumes and Figure 13 displays the HOV Lane Alternative 5B mainline volumes at each of the study area locations, they are the same volumes as 2A and 2B, respectively. Therefore,

freeway mainline conditions under HOV Lane Alternative 5A results would be the same as with No Build, as shown in Table 4-17.

For HOV Lane Alternative 5B, both the direct HOV ramps at Main Street would be eliminated, thereby requiring users of these ramps to relocate to other ramps in the area. As a result, there would be changes in the freeway access patterns and thus minor differences in freeway mainline volumes, as shown in Table 4-18.

During Opening Year (2018), 9 of the 12 analysis segments on the I-5 Freeway are forecast to operate at LOS E/F during the weekday AM peak hour, and 10 of the 12 segments are forecasted to operate at LOS E/F during the weekday PM peak hour, as shown in Table 4-18. HCS development worksheets can be found in Appendix C.

Table 4-17: Freeway Mainline LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternatives 5A

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			GP	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
1	SR-57 between Chapman off-ramp and SR-22 off-ramp	SB	3	0	**7,490**	**>45.0**	**F**	**7,670**	**>45.0**	**F**
2	I-5 between Chapman on-ramp and SR-22 off-ramp	SB	5	2	9,170	32.2	D	8,050	27.2	D
5	I-5 between Main on-ramp and 17th/Penn off-ramp	SB	5	1	**10,075**	**38.0**	**E**	**9,705**	**35.4**	**E**
6	I-5 between 17th on-ramp and Santa Ana off-ramp	SB	5	1	**10,600**	**42.6**	**E**	**10,065**	**38.0**	**E**
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**10,330**	**40.1**	**E**	**10,285**	**39.7**	**E**
9	I-5 between Fourth off-ramp and First Street on-ramp	SB	5	1	9,595	34.7	D	**9,805**	**36.1**	**E**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**11,790**	**>45.0**	**F**	**9,754**	**35.7**	**E**
6	I-5 between Grand Ave on-ramp and 17th off-ramp	NB	5	1	**11,125**	**>45.0**	**F**	9,149	32.1	D
5	I-5 between 17th on-ramp and Main/Broadway off-ramp	NB	5	1	**11,640**	**>45.0**	**F**	**10,379**	**40.5**	**E**
4	I-5 between Main on-ramp and SR-22 exit	NB	4	1	**9,515**	**>45.0**	**F**	**9,219**	**>45.0**	**F**
2	I-5 between SR-22 on-ramp and Chapman off-ramp	NB	5	1	9,395	33.5	D	**10,364**	**40.4**	**E**
1	SR-57 between Chapman off-ramp and Chapman on-ramp	NB	3	0	**7,485**	**>45.0**	**F**	**6,235**	**41.2**	**E**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

Table 4-18:Freeway Mainline LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternatives 5B

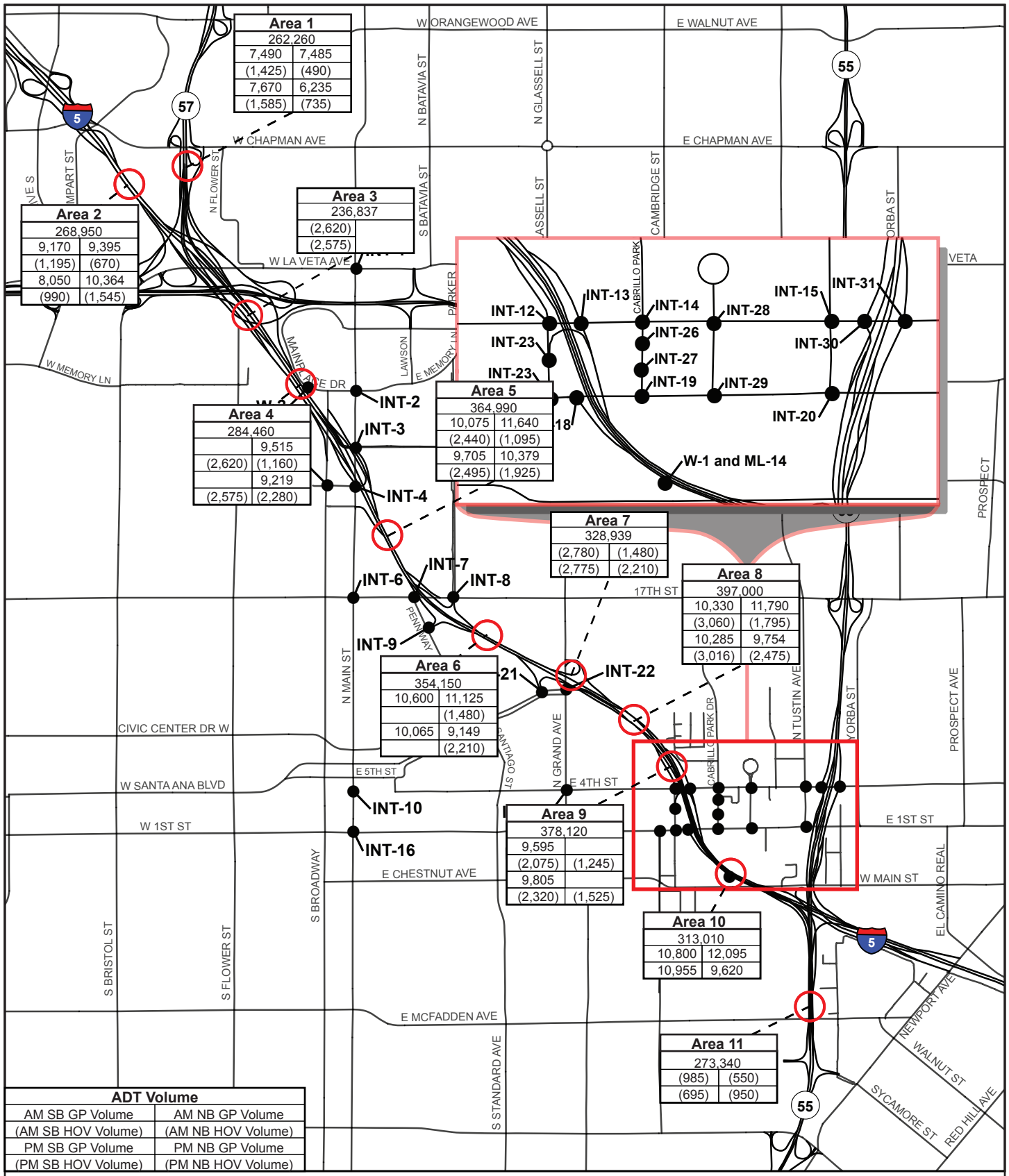
Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			GP	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
1	SR-57 between Chapman off-ramp and SR-22 off-ramp	SB	3	0	**7,490**	**66.4**	**F**	**7,670**	**72.4**	**F**
2	I-5 between Chapman on-ramp and SR-22 off-ramp	SB	5	2	9,351	33.3	D	8,129	27.8	D
5	I-5 between Main on-ramp and 17th/Penn off-ramp	SB	5	1	**10,098**	**38.2**	**E**	**9,712**	**35.5**	**E**
6	I-5 between 17th on-ramp and Santa Ana off-ramp	SB	5	1	**10,600**	**42.6**	**E**	**10,065**	**38.0**	**E**
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**10,330**	**40.1**	**E**	**10,285**	**39.7**	**E**
9	I-5 between Fourth off-ramp and First Street on-ramp	SB	5	1	9,595	34.7	D	**9,805**	**36.1**	**E**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**11,790**	**>45.0**	**F**	**9,754**	**35.7**	**E**
6	I-5 between Grand Ave on-ramp and 17th off-ramp	NB	5	1	**11,125**	**>45.0**	**F**	9,149	32.1	D
5	I-5 between 17th on-ramp and Main/Broadway off-ramp	NB	5	1	**11,656**	**>45.0**	**F**	**10,445**	**41.1**	**E**
4	I-5 between Main on-ramp and SR-22 exit	NB	4	1	**9,584**	**>45.0**	**F**	**9,518**	**>45.0**	**F**
2	I-5 between SR-22 on-ramp and Chapman off-ramp	NB	5	1	9,449	33.8	D	**10,668**	**43.2**	**E**
1	SR-57 between Chapman off-ramp and Chapman on-ramp	NB	3	0	**7,485**	**66.2**	**F**	**6,235**	**41.2**	**E**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

4.3.2 HOV LANE PERFORMANCE

HOV lane analysis results for the HOV Lane Alternatives 5A and 5B are summarized in Table 4-19 and Table 4-20. With the addition of the second HOV lane between SR-55 and SR-57, the number of vehicles able to use the HOV lanes would increase due to the elimination of the northbound and southbound bottleneck locations (the lane reductions at the I-5 southbound / SR-57 southbound connection and at the I-5 northbound / SR-55 northbound connection would be eliminated). For both alternatives, operating conditions would improve above No Build at locations where the second lane was added and there would be substantial increases in throughput in both directions (up to 1,070 vph in the weekday AM peak hour and 1,025 vph in the weekday PM peak hour for Alternative 5A, and up to 1,030 vph in the weekday AM peak hour and 1,010 vph in the weekday PM peak hour for Alternative 5B). At the northern end of the study area, HOV lane volumes for Alternative 5B would be slightly less than for Alternative 5A due to the elimination of the direct HOV entrance and exit ramps at Main Street.

With the HOV Lane Alternatives, there is also projected to be an additional HOV demand over and above the No Build demand – additional vehicles would be attracted to the HOV facility due to its additional capacity and the elimination of the bottlenecks (400 vph in the weekday AM peak hour and 385 vph in the weekday PM peak hour).



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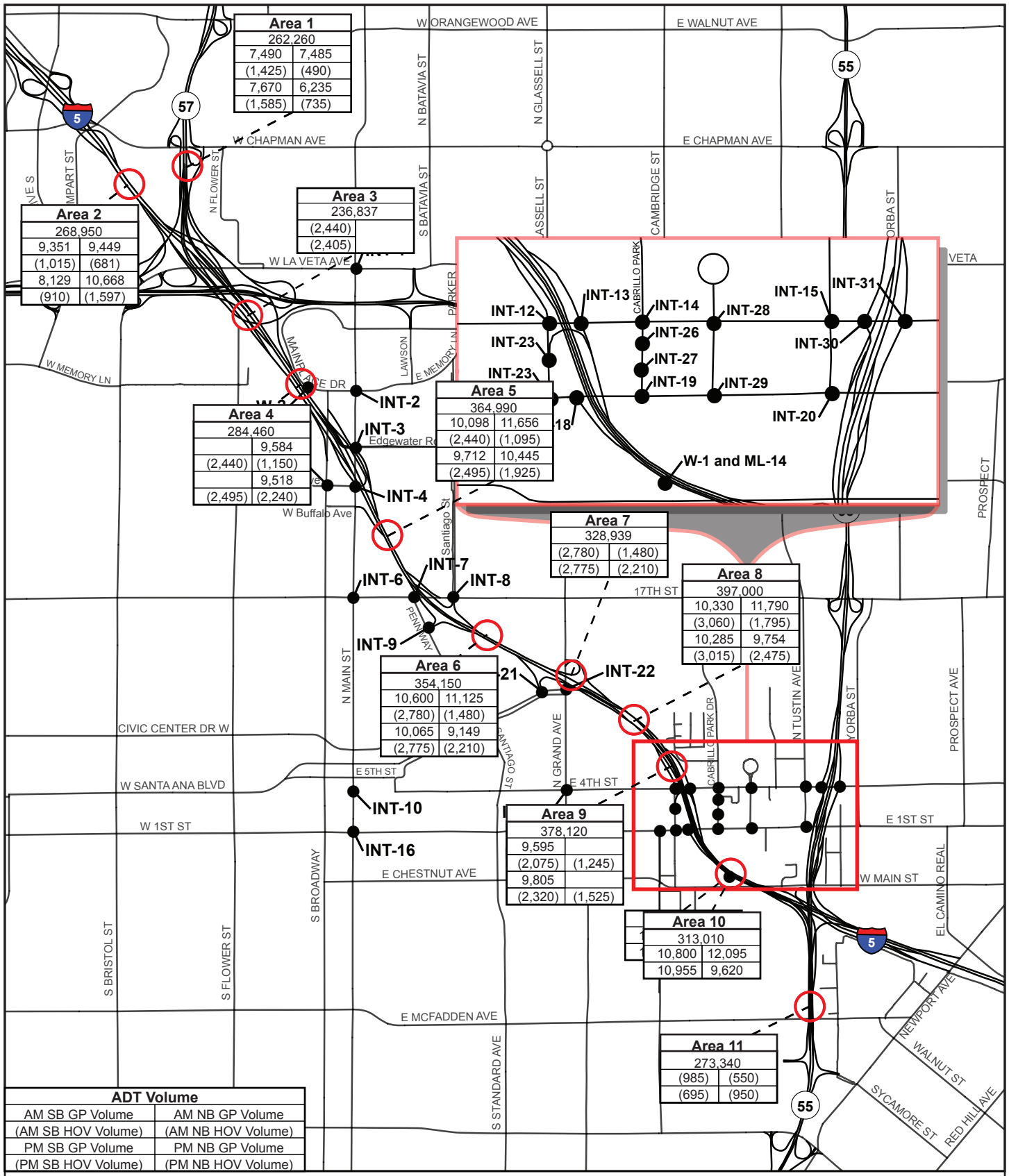
I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED
Figure 12 – I-5 Freeway Volumes – 2018 5A



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I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED

Figure 13 – I-5 Freeway Volumes – 2018 5B

Overall, under the Year 2018 conditions, all analysis locations would operate at LOS D or better, with the exception of the southbound I-5 HOV lane directly south of the SR-55 exit. In this location, the additional throughput that would be allowed in the HOV lanes with the project and would continue south along I-5 could not be accommodated in the single HOV lane after the SR-55 split. As a result, the HOV lane would be over-capacity under both HOV Lane Alternatives, leading to LOS F conditions and minor congestion, which would result in some delays to HOV users.

HOV lane calculations are provided in Appendix D.

Table 4-19: HOV LOS Summary – Opening Year (2018) Conditions - HOV Lane Alternative 5A

Map Ref #	Location		# of Lanes	AM Peak Hour			PM Peak Hour		
				Vol.	Capacity (V/C)	LOS	Vol.	Capacity (V/C)	LOS
1	SR-57 north of I-5 HOV merge	SB	1	1,425	0.75	D	1,585	0.83	D
2	I-5 north of SR-57 HOV merge	SB	1	1,195	0.63	C	990	0.52	C
3	I-5 at SR-57 HOV merge	SB	2	2,620	0.69	C	2,575	0.68	C
4	I-5 between SR-57 HOV merge and Main HOV off-ramp	SB	2	2,620	0.69	C	2,575	0.68	C
5	I-5 between Main HOV off-ramp and HOV entrance south of Lincoln overcrossing	SB	2	2,440	0.64	C	2,495	0.66	C
7	I-5 between HOV entrance and Grand HOV on-ramp	SB	2	2,780	0.73	D	2,775	0.73	D
8	I-5 between Grand HOV on-ramp and SR-55 HOV diverge	SB	2	3,060	0.81	D	3,015	0.79	D
9	I-5 south of SR-55 HOV diverge	SB	1	***2,075***	***1.09***	***F***	***2,320***	***1.22***	***F***
11	SR-55 south of I-5 HOV diverge	SB	1	985	0.52	C	695	0.37	B
11	SR-55 south of I-5 HOV merge	NB	1	550	0.29	A	950	0.50	C
9	I-5 south of SR-55 HOV merge	NB	1	1,245	0.66	C	1,525	0.80	D
8	I-5 between SR-55 HOV merge and Grand HOV off-ramp	NB	2	1,795	0.47	B	2,475	0.65	C
7	I-5 at HOV lane merge (2 to 1 lane)	NB	2	1,480	0.39	B	2,210	0.58	C
6	I-5 between HOV lane merge and HOV lane exit north of Lincoln overcrossing	NB	2	1,480	0.39	B	2,210	0.58	C
5	I-5 between HOV exit and Main HOV off-ramp	NB	2	1,095	0.29	A	1,925	0.51	C
4	I-5 between Main HOV on-ramp and SR-57 diverge	NB	2	1,160	0.31	B	2,280	0.60	C
2	I-5 north of SR-57 diverge	NB	1	670	0.35	B	1,545	0.81	D
1	SR-57 north of I-5 HOV diverge	NB	1	490	0.26	A	735	0.39	B

Source: AECOM, 2012.
Notes: **Bold** indicates HOV segment operating at LOS E/F. *Italics* indicate locations where the HOV lane has greater than 1,600 vphpl for 1-lane segment; 1,750 vphpl for 2-lane segment.

Table 4-20: HOV LOS Summary – Opening Year (2018) Conditions - HOV Lane Alternative 5B

Map Ref #	Location		# of Lanes	AM Peak Hour			PM Peak Hour		
				Vol.	Capacity (V/C)	LOS	Vol.	Capacity (V/C)	LOS
1	SR-57 north of I-5 HOV merge	SB	1	1,425	0.75	D	1,585	0.83	D
2	I-5 north of SR-57 HOV merge	SB	1	1,015	0.53	C	910	0.48	B
3	I-5 at SR-57 HOV merge	SB	2	2,440	0.64	C	2,495	0.66	C
4	I-5 between SR-57 HOV merge and Main HOV off-ramp	SB	2	2,440	0.64	C	2,495	0.66	C
5	I-5 between Main HOV off-ramp and HOV entrance south of Lincoln overcrossing	SB	2	2,440	0.64	C	2,495	0.66	C
7	I-5 between HOV entrance and Grand HOV on-ramp	SB	2	2,780	0.73	D	2,775	0.73	D
8	I-5 between Grand HOV on-ramp and SR-55 HOV diverge	SB	2	3,060	0.81	D	3,015	0.79	D
9	I-5 south of SR-55 HOV diverge	SB	1	***2,075***	***1.09***	***F***	***2,320***	***1.22***	***F***
11	SR-55 south of I-5 HOV diverge	SB	1	985	0.52	C	695	0.37	B
11	SR-55 south of I-5 HOV merge	NB	1	550	0.29	A	950	0.50	C
9	I-5 south of SR-55 HOV merge	NB	1	1,245	0.66	C	1,525	0.80	D
8	I-5 between SR-55 HOV merge and Grand HOV off-ramp	NB	2	1,795	0.47	B	2,475	0.65	C
7	I-5 at HOV lane merge (2 to 1 lane)	NB	2	1,480	0.39	B	2,210	0.58	C
6	I-5 between HOV lane merge and HOV lane exit north of Lincoln overcrossing	NB	2	1,480	0.39	B	2,210	0.58	C
5	I-5 between HOV exit and Main HOV off-ramp	NB	2	1,095	0.29	A	1,925	0.51	C
4	I-5 between Main HOV on-ramp and SR-57 diverge	NB	2	1,150	0.30	B	2,240	0.59	C
2	I-5 north of SR-57 diverge	NB	1	681	0.36	B	1,597	0.84	D
1	SR-57 north of I-5 HOV diverge	NB	1	490	0.26	A	735	0.39	B

Source: AECOM, 2012.
Notes: **Bold** indicates HOV segment operating at LOS E/F. *Italics* indicate locations where the HOV lane has greater than 1,600 vphpl for 1-lane segment; 1,750 vphpl for 2-lane segment.

Although the results for Alternatives 5A and 5B are similar to that of Alternatives 2A and 2B, Alternatives 5A and 5B would perform slightly better with respect to weaving. As noted previously, Alternatives 5A and 5B would not create internal HOV weaving segment that occurs with Alternatives 2A and 2B as both lanes would be on the same side of the concrete barrier. Due to the presence of this barrier in Alternatives 2A and 2B, vehicles in the northbound SR-55 HOV connector would need to weave to exit the HOV lane to access 17th Street, Main Street or SR-22. If these vehicles were to miss this exit, the next available opening would not be available until the SR-57 overcrossing under Alternatives 2A and 2B. Conversely, Alternatives 5A and 5B would provide HOV lane exits to 17th Street, Main Street, and the SR-22 via openings of the concrete barrier, and thus would perform slightly better than Alternatives 2A and 2B by not creating an internal weave within the HOV lanes.

4.3.3 WEAVING PERFORMANCE

With HOV Lane Alternative 5A, conditions at the I-5 Freeway weaving segment would be the same as with No Build, as there would be no change to freeway mainline or Main Street on-ramp volumes with Alternative 2A, as shown in Tables 4-21 and 4-22. Weaving calculations can be seen in Appendix E.

Table 4-21: HCM Weaving LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternative 5A

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**38.9**	**E**	**0.89**	**41.9**	**E**	**0.92**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 4-22: HDM Weaving LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternative 5A

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

However, since Alternative 5B would eliminate the Main Street direct HOV on-ramp, there would be an increase in volumes along both the freeway mainline and at the Main Street general-purpose on-ramp, as shown in Table 4-23 and Table 4-24. As a result, weaving conditions under Alternative 5B would be slightly worse during both the weekday AM and PM peak hours.

Table 4-23: HCM Weaving LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternative 5B

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**39.2**	**E**	**0.89**	**44.7**	**E**	**0.96**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 4-24: HDM Weaving LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternative 5B

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

4.3.4 INTERSECTION OPERATIONS

A level of service analysis was conducted to evaluate Opening Year (2018) Alternatives 5A and 5B intersection operating conditions during the weekday AM and PM peak hours. Table 4-25 summarizes the Opening Year (2018) Alternative 5A and 5B level of service at the study area intersections. Traffic volumes for Opening Year (2018) Alternative 5A and 5B are included in Appendix B. Level of service calculation worksheets are included in Appendix F. With Alternative 5A, the increase in activity along the HOV lanes, due to the second HOV lane in each direction, would result in minor increases in intersection volumes at intersections near the Main Street direct HOV ramps. For Alternative 5B, with the closure of the Main Street I-5 HOV entrance and exit ramps, there would be a redistribution of vehicles in the study area, as high-occupant vehicles would need to find alternative ramps to travel to and from I-5 as discussed in Section 3.3. The redistribution of vehicles can found in Appendix B. For each affected local intersection, minor modifications to signal timing (no geometric changes) were applied where applicable to account for additional vehicles that were redistributed as part of the alternatives.

Table 4-20 reflects only the locations where the LOS changes from the No Build (i.e., does not include intersections affected by the Ramp Alternatives). Under both Alternatives 5A and 5B, all study intersections would continue to operate acceptably at LOS D or better.

Table 4-25: Intersection LOS Summary – Opening Year (2018) Conditions – HOV Lane Alternatives 5A and 5B

ID	Intersection	2018 HOV Alt 5A Conditions				2018 HOV Alt 5B Conditions			
		AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS
1	Main / La Veta	19.8	B	26.4	C	19.8	B	26.4	C
2	Main / Memory	17.1	B	21.3	C	17.1	B	21.3	C
3	Main / Edgewood / I-5	40.4	D	52.3	D	36.5	D	40.5	D
4	Broadway / Santa Clara	30.2	C	28.1	C	30.2	C	28.1	C
5	Main / Santa Clara / I-5+	43.0	D	51.2	D	43.0	D	51.2	D
6	Main / 17th+	42.9	D	49.9	D	42.9	D	49.9	D
7	Penn / 17th	10.8	B	13.6	B	10.8	B	13.6	B
8	Santiago / 17th	32.6	C	35.5	D	32.6	C	35.5	D
9	Penn / I-5 SB Ramp	24.4	C	23.1	C	24.4	C	23.1	C

Source: AECOM, 2012

Notes:
+ Minor intersection signal timing adjustments made to account for additional vehicles that were redistributed as part of HOV Lane Alternatives 5A and 5B.
Bold indicates intersection operating at unacceptable LOS.
[1] Delay is shown in seconds per vehicle. For signalized locations, delay reported is average delay of all approaches.

4.3.5 RAMP QUEUING

The queuing analysis results of the Opening Year (2018) No Build, HOV Lane Alternatives 5A and 5B during AM and PM peak hours are presented in Table 4-26. As with No Build conditions, queues that would develop under the HOV Lane Alternatives 5A and 5B could be accommodated within the available storage distance. HOV Lane Alternative 5A would have queue lengths almost identical to No Build conditions. HOV Lane Alternative 5B would have increased queue lengths at the off-ramps due to more vehicles exiting at these locations from the elimination of the Main Street HOV ramps. Queue length calculations can be found in Appendix G.

Table 4-26: Ramp Queuing Summary – Opening Year (2018) Conditions – HOV Lane Alternatives 5A and 5B

Map Ref #	Off-Ramp Location	Controlling Intersection Approach	Available Storage Length (feet)	Percentile	2018 5A		2018 5B	
					AM Queue Length (feet)	PM Queue Length (feet)	AM Queue Length (feet)	PM Queue Length (feet)
3	Main / Edgewood / I-5	Northwest	1,357	50th	432	161	432	161
				95th	664	264	664	266
3	Main / Edgewood / I-5 (HOV off-ramp)	Eastbound	1,353	50th	24	19	82	127
				95th	129	94	239	333
5	Main / Santa Clara / I-5	Southeast	1,060	50th	290	268	290	358
				95th	535	459	535	555
22	Grand / Santa Ana (HOV off-ramp)	Westbound	1,538	50th	102	78	102	86
				95th	149	122	149	131

Source: AECOM, 2012.

4.4 FUTURE YEAR (2040) NO BUILD

4.4.1 FREEWAY MAINLINE PERFORMANCE

Figure 14 displays the mainline volumes at each of the study area location. As shown in Table 4-27, during the AM peak hour, all of the 12 analysis segments on the I-5 Freeway are forecast to operate at LOS E or F during both the weekday AM and PM peak hours during Future Year (2040) No Build conditions, with the exception of the southbound I-5 south of the Chapman Avenue on-ramp which would operate at LOS D conditions during the weekday PM peak hour. HCS development worksheets can be found in Appendix C.

Table 4-27: Freeway Mainline LOS Summary – Future Year (2040) Conditions – No Build

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			GP	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
1	SR-57 between Chapman off-ramp and SR-22 off-ramp	SB	3	0	**8,005**	**>45.0**	**F**	**8,125**	**>45.0**	**F**
2	I-5 between Chapman on-ramp and SR-22 off-ramp	SB	5	2	**10,445**	**41.1**	**E**	8,990	31.3	D
5	I-5 between Main on-ramp and 17th/Penn off-ramp	SB	5	1	**11,605**	**>45.0**	**F**	**10,860**	**>45.0**	**F**
6	I-5 between 17th on-ramp and Santa Ana off-ramp	SB	5	1	**12,170**	**>45.0**	**F**	**11,200**	**>45.0**	**F**
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**12,025**	**>45.0**	**F**	**11,490**	**>45.0**	**F**
9	I-5 between Fourth off-ramp and First Street on-ramp	SB	5	1	**11,290**	**>45.0**	**F**	**11,010**	**>45.0**	**F**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**12,433**	**>45.0**	**F**	**10,629**	**42.8**	**E**
6	I-5 between Grand Ave on-ramp and 17th off-ramp	NB	5	1	**11,768**	**>45.0**	**F**	**9,939**	**37.0**	**E**
5	I-5 between 17th on-ramp and Main/Broadway off-ramp	NB	5	1	**12,348**	**>45.0**	**F**	**11,239**	**>45.0**	**F**

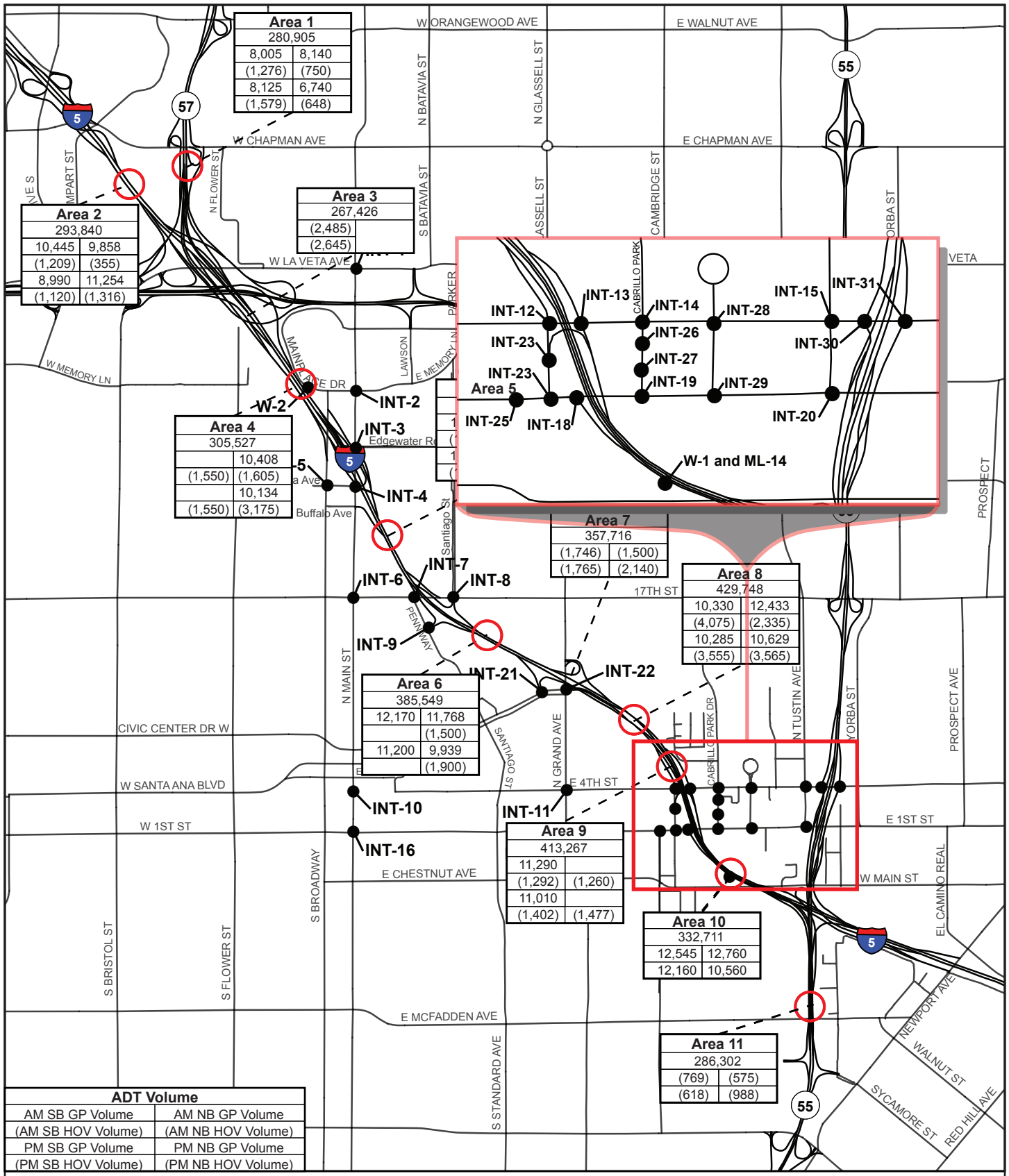
Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			GP	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
4	I-5 between Main on-ramp and SR-22 exit	NB	4	1	**10,408**	**>45.0**	**F**	**10,134**	**>45.0**	**F**
2	I-5 between SR-22 on-ramp and Chapman off-ramp	NB	5	1	**9,858**	**36.5**	**E**	**11,254**	**>45.0**	**F**
1	SR-57 between Chapman off-ramp and Chapman on-ramp	NB	3	0	**8,140**	**>45.0**	**F**	**6,740**	**>45.0**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

4.4.2 HOV LANE PERFORMANCE

Freeway HOV analysis results are summarized in Table 4-28. Forecast AM and PM peak hour HOV volumes by direction and measures of effectiveness are included in Table 4-28. As shown, there are two analysis HOV lane segments during the weekday AM peak hour and five HOV lane segments during the weekday PM peak hour that would operate at LOS E/F. In addition, there are several segments that would have volumes greater than Caltrans's threshold of 1,600 vphpl for one-lane segments and 1,750 vphpl for two-lane segments (3,500 vph total), which indicate that the provided HOV lanes would be over-capacity.

As noted previously, there is a severe bottleneck where the HOV lane from I-5 southbound connects with the HOV lane from SR-57 southbound, with a capacity limit of 1,550 vph. North of this bottleneck, there is currently substantial congestion on both the I-5 southbound and SR-57 SB HOV lanes, which would be worsened under Future Year (2040) Conditions. During the weekday AM and PM peak hours, there would be an un-served demand of about 935 and 1,095 vehicles, respectively, and the merge would operate at LOS F. However, since this bottleneck restricts downstream volumes, analysis locations to the south tend to operate under capacity.



AECOM

I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED
Figure 14 - I-5 Freeway Volumes – 2040 No Build Conditions

Similarly, there is a bottleneck where the HOV lane from I-5 northbound merges with the HOV lane from SR-55 northbound, with a capacity limit of 1,900 vph. At this location, there would be an un-served demand of about 240 vehicles in the weekday PM peak hour, resulting in LOS F conditions and noticeable delays to traffic flows along the I-5 HOV lane. However, since this bottleneck restricts downstream volumes, analysis locations to the north tend to operate under capacity. HOV lane calculations can be seen in Appendix D.

Table 4-28: HOV LOS Summary – Future Year (2040) Conditions – No Build

Map Ref #	Location		# of Lanes	AM Peak Hour			PM Peak Hour		
				Vol.	Capacity (V/C)	LOS	Vol.	Capacity (V/C)	LOS
1	SR-57 north of I-5 HOV merge	SB	1	1,276	0.67	C	1,597	0.84	D
2	I-5 north of SR-57 HOV merge	SB	1	1,209	0.64	C	1,048	0.55	C
3	I-5 at SR-57 HOV merge	SB	1	***2,485***	***1.31***	***F***	***2,645***	***1.39***	***F***
4	I-5 between SR-57 HOV merge and Main HOV off-ramp[1]	SB	1	1,550	0.82	D	1,550	0.82	D
5	I-5 between Main HOV off-ramp and HOV entrance south of Lincoln overcrossing	SB	1	1,406	0.74	D	1,485	0.78	D
7	I-5 between HOV entrance and Grand HOV on-ramp	SB	1	***1,746***	***0.92***	***E***	***1,765***	***0.93***	***E***
8	I-5 between Grand HOV on-ramp and SR-55 HOV diverge	SB	2	2,061	0.54	C	2,020	0.53	C
9	I-5 south of SR-55 HOV diverge	SB	1	1,292	0.68	C	1,402	0.74	D
11	SR-55 south of I-5 HOV diverge	SB	1	769	0.40	B	618	0.33	B
11	SR-55 south of I-5 HOV merge	NB	1	575	0.30	B	988	0.52	C
9	I-5 south of SR-55 HOV merge	NB	1	1,260	0.66	C	1,477	0.78	D
8	I-5 between SR-55 HOV merge and Grand HOV off-ramp	NB	2	1,835	0.48	B	2,465	0.65	C
7	I-5 at HOV lane merge (2 to 1 lane)	NB	1	1,500	0.79	D	***2,140***	***1.13***	***F***
6	I-5 between HOV lane merge and HOV lane exit north of Lincoln overcrossing	NB	1	1,500	0.79	D	***1,900***	***1.00***	***F***
5	I-5 between HOV exit and Main HOV off-ramp	NB	1	1,050	0.55	C	*1,649*	*0.87*	*D*
4	I-5 between Main HOV on-ramp and SR-57 diverge	NB	1	1,105	0.58	C	***1,964***	***1.03***	***F***
2	I-5 north of SR-57 diverge	NB	1	355	0.19	A	1,316	0.69	C
1	SR-57 north of I-5 HOV diverge	NB	1	750	0.39	B	648	0.34	B

Source: AECOM, 2012.
Notes: **Bold** indicates HOV segment operating at LOS E/F. *Italics* indicate locations where the HOV lane has greater than 1,600 vphpl for 1-lane segment; 1,750 vphpl for 2-lane segment.
[1] Bottleneck location that constrains downstream volumes.

4.4.3 WEAVING PERFORMANCE

Under Future Year (2040) conditions, the weaving section on the I-5 Freeway northbound between the Main Street on-ramp and the SR-22 exit would operate at LOS F during both the weekday AM and PM peak hours, as illustrated in Table 4-29. At this location, there would be an increase in density and weaving segment V/C ratio over Future Year (2018)

conditions due to the general increase in volumes in the area. Weaving calculations can be seen in Appendix E.

Table 4-29: HCM Weaving LOS Summary – Future Year (2040) Conditions – No Build

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**>45.0**	**F**	**0.98**	**>45.0**	**F**	**1.02**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

A second methodology using the Highway Design Manual (HDM), as previously described, was utilized to analyze the weaving section and is shown in Table 4-30. Based on HDM, the weaving section would operate at LOS F conditions during both the weekday AM and PM peak hours. Weaving calculations using the HDM methodology are included in Appendix E.

Table 4-30: HDM Weaving LOS Summary – Future Year (2040) Conditions – No Build

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

4.4.4 INTERSECTION OPERATIONS

A level of service analysis was conducted to evaluate Future Year (2040) No Build intersection operating conditions during the weekday AM and PM peak hours. Table 4-31 summarizes the Future Year (2040) No Build level of service at the study area intersections. Traffic volumes for Future Year (2040) are included in Appendix B. Level of service calculation worksheets are included in Appendix F.

As shown in Table 4-31, all of the study area intersections would continue to operate acceptably (LOS D or better) under Future Year (2040) No Build conditions.

Table 4-31: Intersection LOS Summary - Future Year (2040) Conditions– No Build

ID	Intersection	AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS
1	La Veta / Main	19.8	B	25.5	C
2	Main / Memory	16.9	B	21.1	C
3	Main / Edgewood / I-5	36.9	D	45.9	D
4	Broadway / Santa Clara	28.8	C	32.6	C
5	Main / Santa Clara / I-5	39.8	D	37.6	D
6	Main / 17th	44.6	D	37.9	D
7	Penn / 17th	10.9	B	13.8	B
8	Santiago / 17th	33.0	C	36.4	D
9	Penn / I-5 SB Ramp	25.1	C	23.1	C

Source: AECOM, 2012
Notes:
[1] Delay is shown in seconds per vehicle. For signalized locations, delay reported is average delay of all approaches.

4.4.5 RAMP QUEUING

The queuing analysis results of the Future Year (2040) No Build scenarios during the weekday AM and PM peak hours are presented in Table 4-32. Queue length calculations can be found in Appendix G. As with Existing and Opening Year (2018) conditions, queues that would develop under the No Build Alternative could be accommodated within the available storage distance.

Table 4-32: Ramp Queue Summary – Future Year (2040) Conditions – No Build

Map Ref #	Off-Ramp Location	Controlling Intersection Approach	Available Storage Length (feet)	Percentile	AM Queue Length (feet)	PM Queue Length (feet)
3	Main / Edgewood / I-5	Northwest	1,357	50th	391	157
				95th	635	258
3	Main / Edgewood / I-5 (HOV off-ramp)	Eastbound	1,353	50th	20	17
				95th	105	82
5	Main / Santa Clara / I-5	Southeast	1,060	50th	267	384
				95th	504	591
22	Grand / Santa Ana (HOV off-ramp)	Westbound	1,538	50th	100	83
				95th	146	127

Source: AECOM, 2012.

4.5 FUTURE YEAR (2040) HOV LANE ALTERNATIVES 2A AND 2B

This section shows the Future Year (2040) forecast traffic operating conditions under HOV Lane Alternatives 2A and 2B. For both alternatives, a second continuous HOV lane would

be added. Additionally, HOV Lane Alternative 2B includes the closure of the Main Street I-5 HOV entrance and exit ramps.

4.5.1 FREEWAY MAINLINE PERFORMANCE

For the freeway mainline, HOV Lane Alternative 2A is not forecast to have an appreciable effect on traffic volumes as discussed in the Section 2.3 Volume Development. Figure 15 displays the HOV Lane Alternative 2A mainline volumes and Figure 16 displays the HOV Lane Alternative 2B mainline volumes at each of the study area locations. Overall, HOV Lane Alternative 2A results would be the same as the No Build, as shown in Table 4-33.

For HOV Lane Alternative 2B, shown in Table 4-34, local vehicles are required to access the I-5 freeway at general-purpose flow ramps due to the closing of the Main Street I-5 HOV ramps and enter the HOV through an access point along the freeway mainline instead of an HOV-only ramp access point. Thus, higher volumes are projected on the mainline in select locations which filter back into the HOV lane downstream. Under Future Year (2040) conditions, density increases on the mainline in a few locations for the HOV Lane Alternative 2B conditions, but generally LOS does not degrade for either of the peak hours. HCS development worksheets can be found in Appendix C.

Table 4-33: Freeway Mainline LOS Summary – Future Year (2040) Conditions – HOV Lane Alternatives 2A

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			GP	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
1	SR-57 between Chapman off-ramp and SR-22 off-ramp	SB	3	0	**8,005**	**>45.0**	**F**	**8,125**	**>45.0**	**F**
2	I-5 between Chapman on-ramp and SR-22 off-ramp	SB	5	2	**10,445**	**41.1**	**E**	8,990	31.3	D
5	I-5 between Main on-ramp and 17th/Penn off-ramp	SB	5	1	**11,605**	**>45.0**	**F**	**10,860**	**>45.0**	**F**
6	I-5 between 17th on-ramp and Santa Ana off-ramp	SB	5	1	**12,170**	**>45.0**	**F**	**11,200**	**>45.0**	**F**
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**12,025**	**>45.0**	**F**	**11,490**	**>45.0**	**F**
9	I-5 between Fourth off-ramp and First Street on-ramp	SB	5	1	**11,290**	**>45.0**	**F**	**11,010**	**>45.0**	**F**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**12,433**	**>45.0**	**F**	**10,629**	**42.8**	**E**
6	I-5 between Grand Ave on-ramp and 17th off-ramp	NB	5	1	**11,768**	**>45.0**	**F**	**9,939**	**37.0**	**E**
5	I-5 between 17th on-ramp and Main/Broadway off-ramp	NB	5	1	**12,348**	**>45.0**	**F**	**11,239**	**>45.0**	**F**
4	I-5 between Main on-ramp and SR-22 exit	NB	4	1	**10,408**	**>45.0**	**F**	**10,134**	**>45.0**	**F**
2	I-5 between SR-22 on-ramp and Chapman off-ramp	NB	5	1	**9,858**	**36.5**	**E**	**11,254**	**>45.0**	**F**
1	SR-57 between Chapman off-ramp and Chapman on-ramp	NB	3	0	**8,140**	**>45.0**	**F**	**6,740**	**>45.0**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

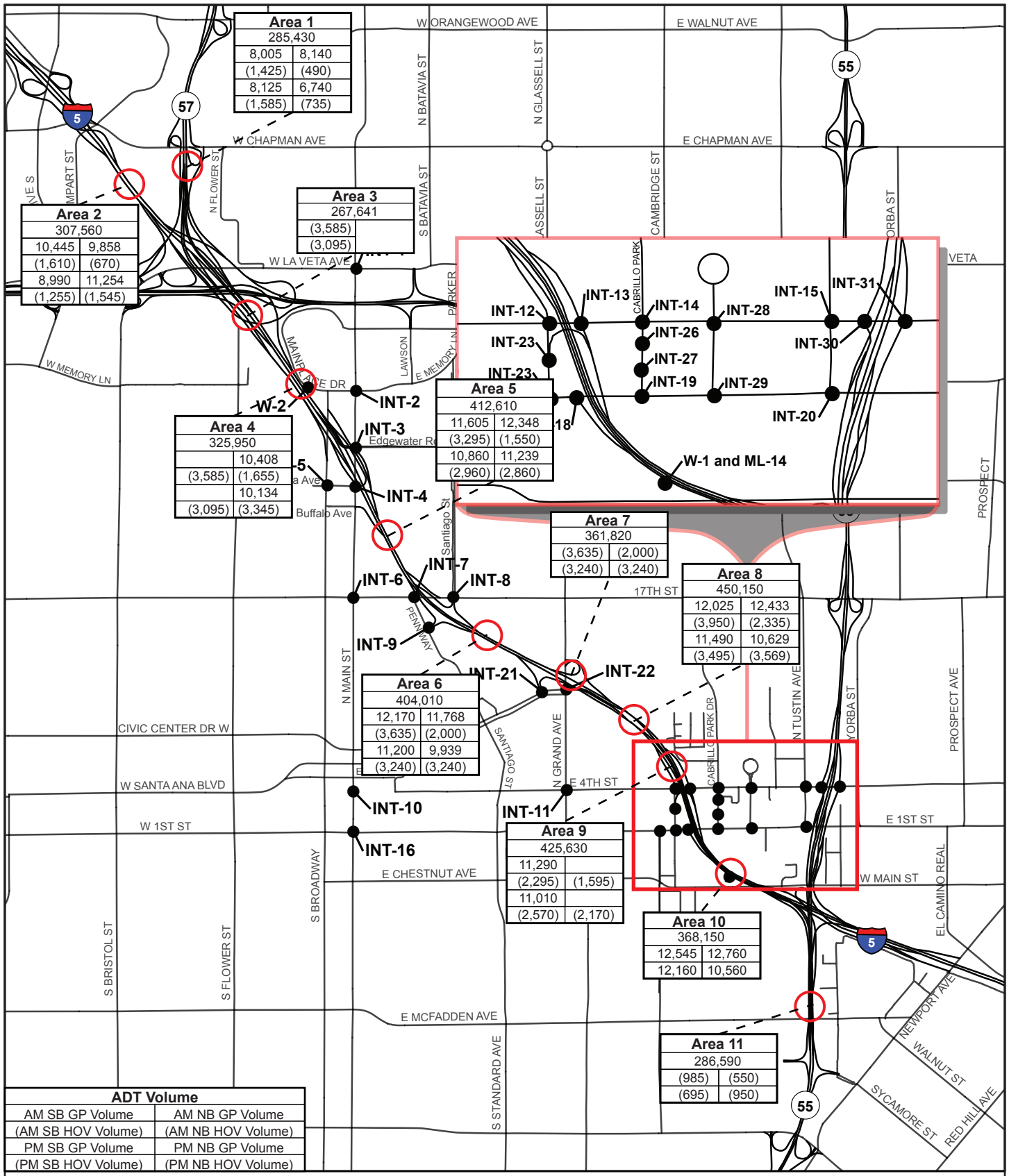
Table 4-34: Freeway Mainline LOS Summary – Future Year (2040) Conditions – HOV Lane Alternatives 2B

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			GP	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
1	SR-57 between Chapman off-ramp and SR-22 off-ramp	SB	3	0	**8,005**	**>45.0**	**F**	**8,125**	**>45.0**	**F**
2	I-5 between Chapman on-ramp and SR-22 off-ramp	SB	5	2	**10,734**	**43.9**	**E**	9,124	32.0	D
5	I-5 between Main on-ramp and 17th/Penn off-ramp	SB	5	1	**11,641**	**>45.0**	**F**	**10,872**	**>45.0**	**F**
6	I-5 between 17th on-ramp and Santa Ana off-ramp	SB	5	1	**12,170**	**>45.0**	**F**	**11,200**	**>45.0**	**F**
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**12,025**	**>45.0**	**F**	**11,490**	**>45.0**	**F**
9	I-5 between Fourth off-ramp and First Street on-ramp	SB	5	1	**11,290**	**>45.0**	**F**	**11,010**	**>45.0**	**F**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**12,433**	**>45.0**	**F**	**10,629**	**42.8**	**E**
6	I-5 between Grand Ave on-ramp and 17th off-ramp	NB	5	1	**11,768**	**>45.0**	**F**	**9,939**	**37.0**	**E**
5	I-5 between 17th on-ramp and Main/Broadway off-ramp	NB	5	1	**12,373**	**>45.0**	**F**	**11,380**	**>45.0**	**F**
4	I-5 between Main on-ramp and SR-22 exit	NB	4	1	**10,501**	**>45.0**	**F**	**10,565**	**>45.0**	**F**
2	I-5 between SR-22 on-ramp and Chapman off-ramp	NB	5	1	**9,927**	**37.8**	**E**	**11,691**	**>45.0**	**F**
1	SR-57 between Chapman off-ramp and Chapman on-ramp	NB	3	0	**8,140**	**>45.0**	**F**	**6,740**	**>45.0**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

4.5.2 HOV LANE PERFORMANCE

HOV lane analysis results for the HOV Lane Alternatives 2A and 2B are summarized in Table 4-35 and Table 4-36. With the addition of the second HOV lane between SR-55 and SR-57, the number of vehicles able to use the HOV lanes would increase due to the elimination of the northbound and southbound bottleneck locations (the lane reductions at the I-5 southbound / SR-57 southbound connection and at the I-5 northbound / SR-55 northbound connection would be eliminated). In addition, there is also projected to be an additional HOV demand over and above the No Build demand – additional vehicles would be attracted to the HOV facility due to its additional capacity and the elimination of the bottlenecks (1,600 vph in the weekday AM peak hour and 1,550 vph in the weekday PM peak hour). Overall, there would be a substantial increase in throughput in both directions (up to 2,035 vph in the AM peak hour and 1,545 vph in the PM peak hour for Alternative 2A, and up to 1,900 vph in the AM peak hour and 1,475 vph in the PM peak hour for Alternative 2B).



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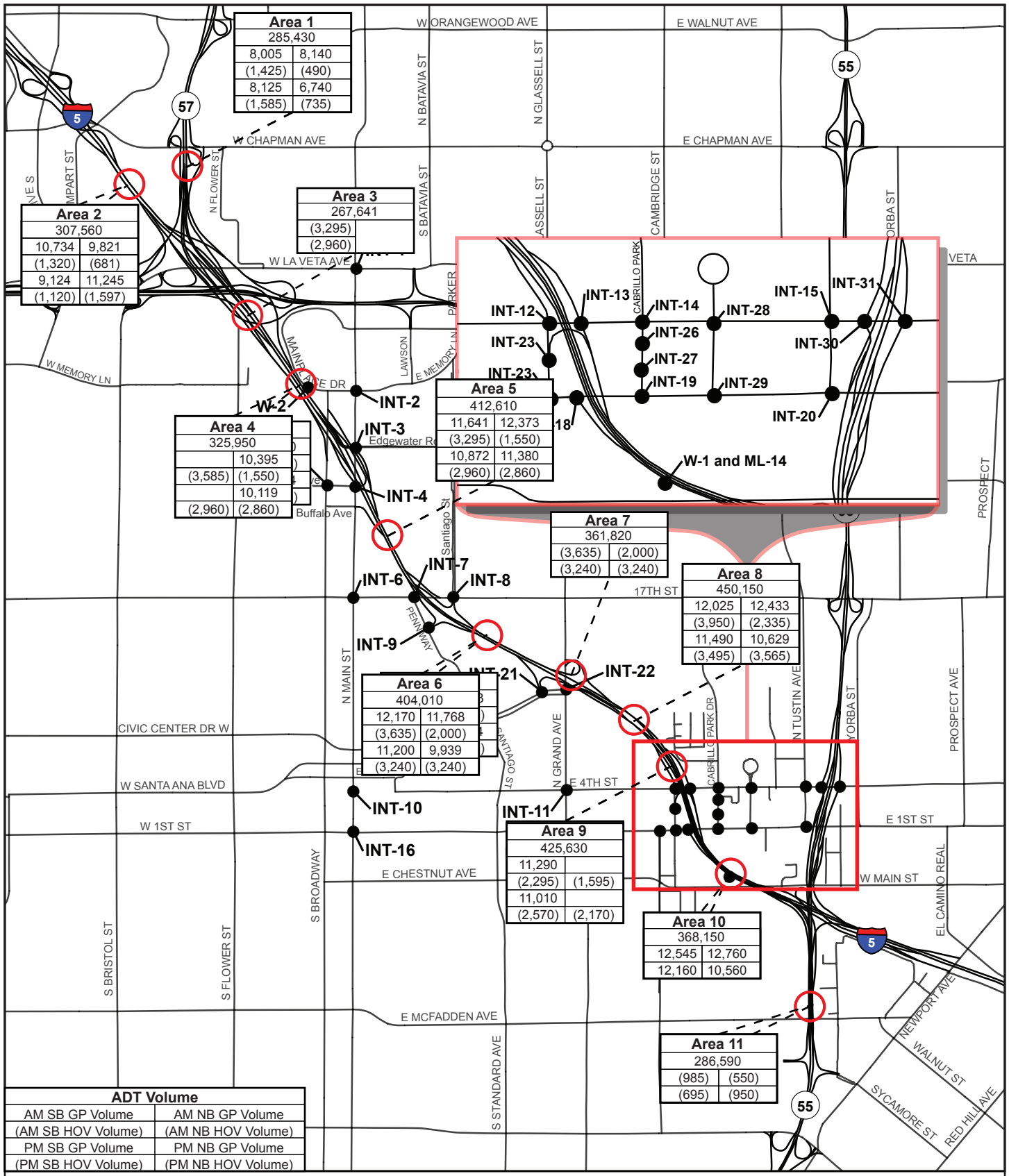
I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED

Figure 15 – I-5 Freeway Volumes – 2040 2A



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I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED
Figure 16 – I-5 Freeway Volumes – 2040 2B

In combination, I-5 HOV lane conditions to the north and south of the study area (i.e., along southbound I-5 north of the SR-57 merge and south of the SR-55 diverge, and along northbound I-5 south of the SR-55 merge and north of the SR-57 diverge) would be over-capacity under both HOV Lane Alternatives, leading to LOS F conditions. These conditions would result in additional delays and congestion to HOV users and the potential formation of additional bottleneck locations. In addition, within the HOV lane segment, at the intermediate access points (such as at the Grand Avenue direct HOV on-ramp to southbound I-5), there would be additional congested locations that would delay HOV lane users.

HOV lane calculations are provided in Appendix D.

Table 4-35: HOV LOS Summary – Future Year (2040) Conditions - HOV Lane Alternative 2A

Map Ref #	Location		# of Lanes	AM Peak Hour			PM Peak Hour		
				Vol.	Capacity (V/C)	LOS	Vol.	Capacity (V/C)	LOS
1	SR-57 north of I-5 HOV merge	SB	1	***1,975***	***1.04***	***F***	***1,840***	***0.97***	***E***
2	I-5 north of SR-57 HOV merge	SB	1	*1,610*	*0.85*	*D*	1,255	0.66	C
3	I-5 at SR-57 HOV merge	SB	2	***3,585***	***0.94***	***E***	3,095	0.81	D
4	I-5 between SR-57 HOV merge and Main HOV off-ramp	SB	2	***3,585***	***0.94***	***E***	3,095	0.81	D
5	I-5 between Main HOV off-ramp and HOV entrance south of Lincoln overcrossing	SB	2	3,295	0.87	D	2,960	0.78	D
7	I-5 between HOV entrance and Grand HOV on-ramp	SB	2	***3,635***	***0.96***	***E***	3,240	0.85	D
8	I-5 between Grand HOV on-ramp and SR-55 HOV diverge	SB	2	***3,950***	***1.04***	***F***	**3,495**	**0.92**	**E**
9	I-5 south of SR-55 HOV diverge	SB	1	***2,295***	***1.21***	***F***	***2,570***	***1.35***	***F***
11	SR-55 south of I-5 HOV diverge	SB	1	*1,655*	*0.87*	*D*	925	0.49	B
11	SR-55 south of I-5 HOV merge	NB	1	740	0.39	B	1,395	0.73	D
9	I-5 south of SR-55 HOV merge	NB	1	1,595	0.84	D	***2,170***	***1.14***	***F***
8	I-5 between SR-55 HOV merge and Grand HOV off-ramp	NB	2	2,335	0.61	C	***3,565***	***0.94***	***E***
7	I-5 at HOV lane merge (2 to 1 lane)	NB	2	2,000	0.53	C	3,240	0.85	D
6	I-5 between HOV lane merge and HOV lane exit north of Lincoln overcrossing	NB	2	2,000	0.53	C	3,240	0.85	D
5	I-5 between HOV exit and Main HOV off-ramp	NB	2	1,550	0.41	B	2,860	0.75	D
4	I-5 between Main HOV on-ramp and SR-57 diverge	NB	2	1,655	0.44	B	3,345	0.88	D
2	I-5 north of SR-57 diverge	NB	1	905	0.48	B	***2,315***	***1.22***	***F***
1	SR-57 north of I-5 HOV diverge	NB	1	750	0.39	B	1,030	0.54	C

Source: AECOM, 2012.
Notes: **Bold** indicates HOV segment operating at LOS E/F. *Italics* indicate locations where the HOV lane has greater than 1,600 vphpl for 1-lane segment; 1,750 vphpl for 2-lane segment.

Table 4-36: HOV LOS Summary – Future Year (2040) Conditions - HOV Lane Alternative 2B

Map Ref #	Location		# of Lanes	AM Peak Hour			PM Peak Hour		
				Vol.	Capacity (V/C)	LOS	Vol.	Capacity (V/C)	LOS
1	SR-57 north of I-5 HOV merge	SB	1	***1,975***	***1.04***	***F***	***1,840***	***0.97***	***E***
2	I-5 north of SR-57 HOV merge	SB	1	1,320	0.69	C	1,255	0.66	C
3	I-5 at SR-57 HOV merge	SB	2	3,295	0.87	D	2,960	0.78	D
4	I-5 between SR-57 HOV merge and Main HOV off-ramp	SB	2	3,295	0.87	D	2,960	0.78	D
5	I-5 between Main HOV off-ramp and HOV entrance south of Lincoln overcrossing	SB	2	3,295	0.87	D	2,960	0.78	D
7	I-5 between HOV entrance and Grand HOV on-ramp	SB	2	***3,635***	***0.96***	***E***	3,240	0.85	D
8	I-5 between Grand HOV on-ramp and SR-55 HOV diverge	SB	2	***3,950***	***1.04***	***F***	**3,495**	**0.92**	**E**
9	I-5 south of SR-55 HOV diverge	SB	1	***2,295***	***1.21***	***F***	***2,570***	***1.35***	***F***
11	SR-55 south of I-5 HOV diverge	SB	1	*1,655*	*0.87*	*D*	925	0.49	B
11	SR-55 south of I-5 HOV merge	NB	1	740	0.39	B	1,395	0.73	D
9	I-5 south of SR-55 HOV merge	NB	1	1,595	0.84	D	***2,170***	***1.14***	***F***
8	I-5 between SR-55 HOV merge and Grand HOV off-ramp	NB	2	2,335	0.61	C	***3,565***	***0.94***	***E***
7	I-5 at HOV lane merge (2 to 1 lane)	NB	2	2,000	0.53	C	3,240	0.85	D
6	I-5 between HOV lane merge and HOV lane exit north of Lincoln overcrossing	NB	2	2,000	0.53	C	3,240	0.85	D
5	I-5 between HOV exit and Main HOV off-ramp	NB	2	1,550	0.41	B	2,860	0.75	D
4	I-5 between Main HOV on-ramp and SR-57 diverge	NB	2	1,550	0.41	B	2,860	0.75	D
2	I-5 north of SR-57 diverge	NB	1	836	0.44	B	***1,958***	***1.03***	***F***
1	SR-57 north of I-5 HOV diverge	NB	1	750	0.39	B	1,030	0.54	C

Source: AECOM, 2012.
Notes: **Bold** indicates HOV segment operating at LOS E/F. *Italics* indicate locations where the HOV lane has greater than 1,600 vphpl for 1-lane segment; 1,750 vphpl for 2-lane segment.

Alternatives 2A and 2B would introduce a new weaving segment when compared to conditions under Existing conditions and with Alternatives 5A and 5B. The presence of a barrier in Alternatives 2A and 2B beginning south of the Lincoln Avenue overcrossing creates a new weave segment between HOV vehicles originating from the northbound SR-55 HOV connector and those destined to 17th Street, Main Street, or SR-22 via the northbound I-5 HOV lane. Based on a review of local trip destinations, it is anticipated that only a small portion of the 730 AM and 1,395 PM peak hour SR-55 HOV vehicles would weave to access the HOV lane exit. Given the distance available to exit (over 1,500 feet), it is anticipated that this weaving activity would not disrupt HOV lane operations. It should be noted that if HOV vehicles destined to 17th Street, Main Street, or SR-22 miss the exit at this location, the next available exit would not be until the SR-57 overcrossing.

4.5.3 WEAVING PERFORMANCE

With HOV Lane Alternative 2A, conditions at the I-5 Freeway weaving segment would be the same as with No Build, as there would be no change to freeway mainline or Main Street on-ramp volumes with Alternative 2A, as shown in Tables 4-37 and 4-38. Weaving calculations can be seen in Appendix E.

Table 4-37: HCM Weaving LOS Summary – Future Year (2040) Conditions – HOV Lane Alternative 2A

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**>45.0**	**F**	**0.98**	**>45.0**	**F**	**1.02**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1]Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2]V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 4-38: HDM Weaving LOS Summary – Future Year (2040) Conditions – HOV Lane Alternative 2A

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
NB I-5 between Main on-ramp and SR-22 exit	NB	1,650	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1]*Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

However, since Alternative 2B would eliminate the Main Street direct HOV on-ramp, there would be an increase in volumes along both the freeway mainline and at the Main Street general-purpose on-ramp, as shown in Tables 4-39 and 4-40. As a result, weaving conditions under Alternative 2B would be slightly worse during both the weekday AM and PM peak hours.

Table 4-39: HCM Weaving LOS Summary – Future Year (2040) Conditions – HOV Lane Alternative 2B

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
NB I-5 between Main on-ramp and SR-57 off-ramp	NB	1,650	**>45.0**	**F**	**0.98**	**>45.0**	**F**	**1.05**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1]Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2]V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 4-40: HDM Weaving LOS Summary – Future Year (2040) Conditions – HOV Lane Alternative 2B

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
NB I-5 between Main on-ramp and SR-57 off-ramp	NB	1,650	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

4.5.4 INTERSECTION OPERATIONS

A level of service analysis was conducted to evaluate Future Year (2040) Alternatives 2A and 2B intersection operating conditions during the weekday AM and PM peak hours. Table 4-41 summarizes the Future Year (2040) Alternatives 2A and 2B level of service at the study area intersections. With Alternative 2A, the increase in volume along the HOV lanes, due to the second HOV lane in each direction, would result in minor increases in intersection volumes at intersections near the Main Street direct HOV ramps. For Alternative 2B, with the closure of the Main Street I-5 HOV entrance and exit ramps, there would be a redistribution of vehicles in the study area, as high-occupant vehicles would need to find alternative ramps to travel to and from I-5 as discussed in Section 3.3. The redistribution of vehicles can found in Appendix B. For each affected local intersection, minor modifications to signal timing (no geometric changes) were applied where applicable to account for additional vehicles that were redistributed as part of the alternatives. Table 4-41 reflects only the locations where the LOS changes from the No Build (i.e., does not include intersections affected by the Ramp Alternatives).

Table 4-41: Intersection LOS Summary – Future Year (2040) Conditions – HOV Lane Alternative 2A and 2B

ID	Intersection	2040 HOV Alt 2A Conditions				2040 HOV Alt 2B Conditions			
		AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS
1	Main / La Veta	20.0	C	26.5	C	20.1	C	27.5	C
2	Main / Memory	17.2	B	21.6	C	17.0	B	21.4	C
3	Main / Edgewood / I-5	40.3	D	48.6	D	35.9	D	41.0	D
4	Broadway / Santa Clara	30.2	C	35.2	D	31.3	C	36.2	D
5	Main / Santa Clara / I-5+	41.6	D	40.5	D	50.8	D	47.3	D
6	Main / 17th+	50.8	D	41.4	D	48.8	D	54.5	D
7	Penn / 17th	11.0	B	14.0	B	11.1	B	14.5	B
8	Santiago / 17th	34.3	C	39.5	D	34.2	C	39.3	D
9	Penn / I-5 SB Ramp	25.3	C	23.2	C	25.3	C	23.3	C

Source: AECOM, 2012
Notes:
+ Minor intersection signal timing adjustments made to account for additional vehicles that were redistributed as part of HOV Lane Alternatives 2A and 2B.
[1] Delay is shown in seconds per vehicle. For signalized locations, delay reported is average delay of all approaches.

As shown in Table 4-41, all of the study area intersections affected by HOV Lane Alternative 2A and Alternative 2B will continue to operate acceptably (LOS D or better) under Future Year (2040) conditions.

Traffic volumes for Future Year (2040) Alternative 2A and 2B are included in Appendix B. Level of service calculation worksheets are included in Appendix F.

4.5.5 RAMP QUEUING

The queuing analysis results of the Opening Year (2040) HOV Lane Alternatives 2A and 2B during the weekday AM and PM peak hours are presented in Table 4-42. As with No Build conditions, queues that would develop under the HOV Lane Alternatives 2A and 2B could be accommodated within the available storage distance. Queue length calculations can be found in Appendix G**.**

Table 4-42: Ramp Queuing Summary – Future Year (2018) Conditions – HOV Lane Alternatives 5A and 5B

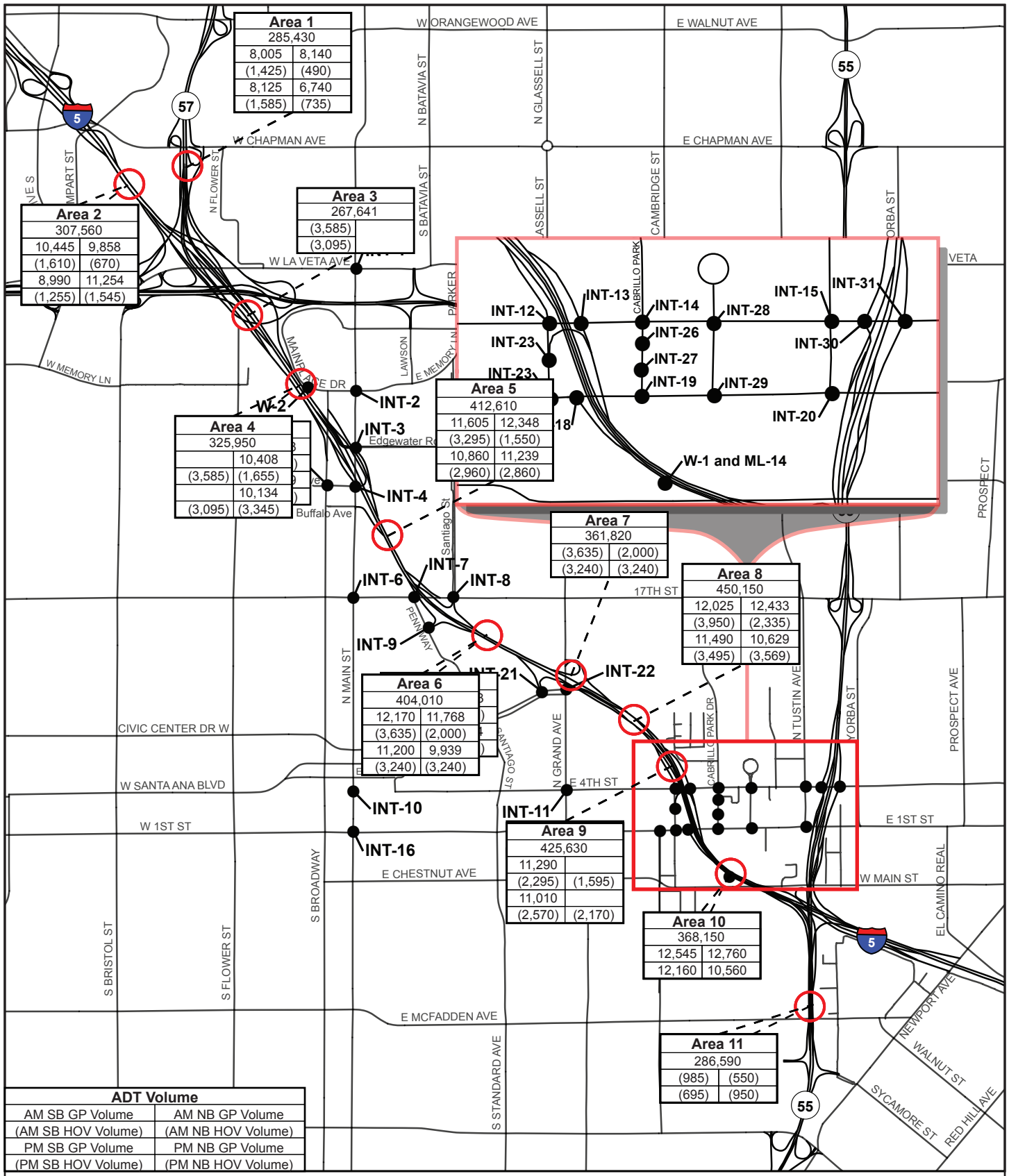
Map Ref #	Off-Ramp Location	Controlling Intersection Approach	Available Storage Length (feet)	Percentile	2040 2A		2040 2B	
					AM Queue Length (feet)	PM Queue Length (feet)	AM Queue Length (feet)	PM Queue Length (feet)
3	Main / Edgewood / I-5	Northwest	1,357	50th	432	161	432	161
				95th	664	270	664	266
3	Main / Edgewood / I-5 (HOV off-ramp)	Eastbound	1,353	50th	66	30	82	157
				95th	250	135	239	333
5	Main / Santa Clara / I-5	Southeast	1,060	50th	246	321	344	358
				95th	486	513	601	555
22	Grand / Santa Ana (HOV off-ramp)	Westbound	1,538	50th	104	86	104	86
				95th	151	131	151	131

Source: AECOM, 2012.

4.6 FUTURE YEAR (2040) HOV LANE ALTERNATIVES 5A AND 5B

4.6.1 FREEWAY MAINLINE PERFORMANCE

For the freeway mainline, HOV Lane Alternative 5A is not projected to have an appreciable effect on traffic volumes as discussed in the Section 2.3 Volume Development. Figure 17 displays HOV Lane Alternative 5A mainline volumes and Figure 18 displays HOV Lane Alternative 5B mainline volumes at each of the study area location. Therefore, HOV Lane Alternative 5A results are the same as the No Build.



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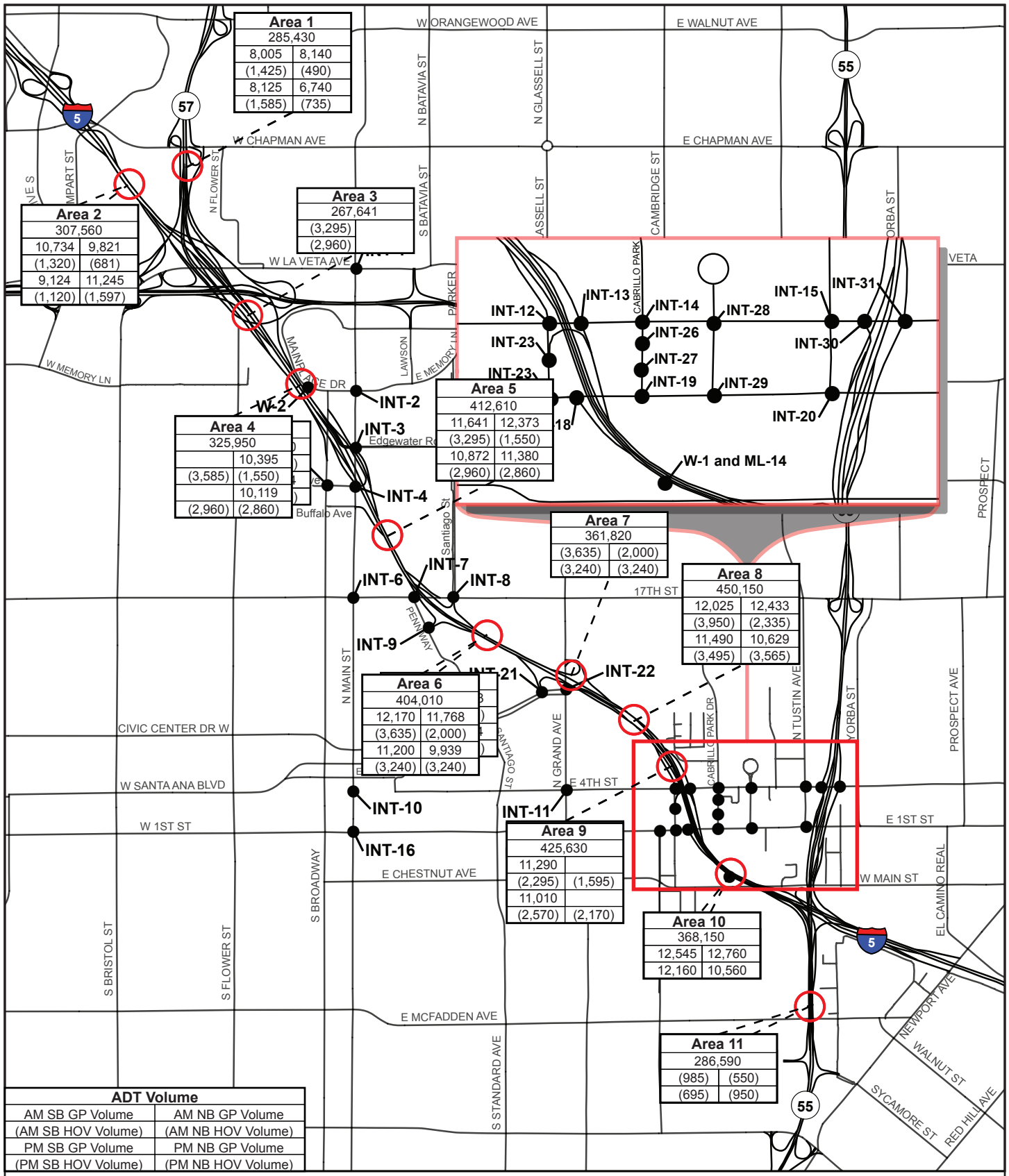
I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED

Figure 17 – I-5 Freeway Volumes – 2040 5A



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I-5 From SR-55 to SR-57 HOV Improvement Project PA/ED
Figure 18 – I-5 Freeway Volumes – 2040 5B

For HOV Lane Alternative 5B, local vehicles would be required to access the I-5 freeway at general-purpose flow ramps due to the closing of the Main Street I-5 HOV ramps and enter the HOV through an access point along the freeway mainline instead of an HOV-only ramp access point. Thus, higher volumes are projected on the mainline in select locations which filter back into the HOV lane downstream.

During Future Year (2040), all of the 12 total basic segments on the I-5 Freeway are forecasted to operate at unsatisfactory LOS E or F during the AM peak hour and 11 of the 12 segments are forecast to operate at unsatisfactory LOS E or F during the PM peak hour as shown in Table 4-43 and Table 4-44. HOV Lane Alternative 5B would not cause conditions to operate worse than the No Build. HCS development worksheets can be found in Appendix C.

Table 4-43: Freeway Mainline LOS Summary – Future Year (2040) Conditions – HOV Lane Alternatives 5A

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			GP	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
1	SR-57 between Chapman off-ramp and SR-22 off-ramp	SB	3	0	**8,005**	**>45.0**	**F**	**8,125**	**>45.0**	**F**
2	I-5 between Chapman on-ramp and SR-22 off-ramp	SB	5	2	**10,445**	**41.1**	**E**	8,990	31.3	D
5	I-5 between Main on-ramp and 17th/Penn off-ramp	SB	5	1	**11,605**	**>45.0**	**F**	**10,860**	**>45.0**	**F**
6	I-5 between 17th on-ramp and Santa Ana off-ramp	SB	5	1	**12,170**	**>45.0**	**F**	**11,200**	**>45.0**	**F**
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**12,025**	**>45.0**	**F**	**11,490**	**>45.0**	**F**
9	I-5 between Fourth off-ramp and First Street on-ramp	SB	5	1	**11,290**	**>45.0**	**F**	**11,010**	**>45.0**	**F**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**12,433**	**>45.0**	**F**	**10,629**	**42.8**	**E**
6	I-5 between Grand Ave on-ramp and 17th off-ramp	NB	5	1	**11,768**	**>45.0**	**F**	**9,939**	**37.0**	**E**
5	I-5 between 17th on-ramp and Main/Broadway off-ramp	NB	5	1	**12,348**	**>45.0**	**F**	**11,239**	**>45.0**	**F**
4	I-5 between Main on-ramp and SR-22 exit	NB	4	1	**10,408**	**>45.0**	**F**	**10,134**	**>45.0**	**F**
2	I-5 between SR-22 on-ramp and Chapman off-ramp	NB	5	1	**9,858**	**36.5**	**F**	**11,254**	**>45.0**	**F**
1	SR-57 between Chapman off-ramp and Chapman on-ramp	NB	3	0	**8,140**	**>45.0**	**F**	**6,740**	**>45.0**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

Table 4-44: Freeway Mainline LOS Summary – Future Year (2040) Conditions – HOV Lane Alternatives 5B

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			GP	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
1	SR-57 between Chapman off-ramp and SR-22 off-ramp	SB	3	0	**8,005**	**>45.0**	**F**	**8,125**	**>45.0**	**F**
2	I-5 between Chapman on-ramp and SR-22 off-ramp	SB	5	2	**10,734**	**43.9**	**E**	9,124	32.0	D
5	I-5 between Main on-ramp and 17th/Penn off-ramp	SB	5	1	**11,641**	**>45.0**	**F**	**10,872**	**>45.0**	**F**
6	I-5 between 17th on-ramp and Santa Ana off-ramp	SB	5	1	**12,170**	**>45.0**	**F**	**11,200**	**>45.0**	**F**
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**12,025**	**>45.0**	**F**	**11,490**	**>45.0**	**F**
9	I-5 between Fourth off-ramp and First Street on-ramp	SB	5	1	**11,290**	**>45.0**	**F**	**11,010**	**>45.0**	**F**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**12,433**	**>45.0**	**F**	**10,629**	**42.8**	**E**
6	I-5 between Grand Ave on-ramp and 17th off-ramp	NB	5	1	**11,768**	**>45.0**	**F**	**9,939**	**37.0**	**E**
5	I-5 between 17th on-ramp and Main/Broadway off-ramp	NB	5	1	**12,373**	**>45.0**	**F**	**11,380**	**>45.0**	**F**
4	I-5 between Main on-ramp and SR-22 exit	NB	4	1	**10,501**	**>45.0**	**F**	**10,565**	**>45.0**	**F**
2	I-5 between SR-22 on-ramp and Chapman off-ramp	NB	5	1	**9,927**	**37.8**	**E**	**11,691**	**>45.0**	**F**
1	SR-57 between Chapman off-ramp and Chapman on-ramp	NB	3	0	**8,140**	**>45.0**	**F**	**6,740**	**>45.0**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

4.6.2 HOV LANE PERFORMANCE

HOV lane analysis results for the HOV Lane Alternatives 5A and 5B are summarized in Table 4-45 and Table 4-46. With the addition of the second HOV lane between SR-55 and SR-57, the number of vehicles able to use the HOV lanes would increase due to the elimination of the northbound and southbound bottleneck locations (the lane reductions at the I-5 southbound / SR-57 southbound connection and at the I-5 northbound / SR-55 northbound connection would be eliminated). In addition, there is also projected to be an additional HOV demand over and above the No Build demand – additional vehicles would be attracted to the HOV facility due to its additional capacity and the elimination of the bottlenecks (1,600 vph in the weekday AM peak hour and 1,550 vph in the weekday PM peak hour). Overall, there would be a substantial increase in throughput in both directions (up to 2,035 vph in the AM peak hour and 1,545 vph in the PM peak hour for Alternative 5A, and up to 1,900 vph in the AM peak hour and 1,475 vph in the PM peak hour for Alternative 5B).

In combination, I-5 HOV lane conditions to the north and south of the study area (i.e., along southbound I-5 north of the SR-57 merge and south of the SR-55 diverge, and along northbound I-5 south of the SR-55 merge and north of the SR-57 diverge) would be over-capacity under both HOV Lane Alternatives, leading to LOS F conditions. These

conditions would result in additional delays and congestion to HOV users and the potential formation of additional bottleneck locations. In addition, within the HOV lane segment, at the intermediate access points (such as at the Grand Avenue direct HOV on-ramp to southbound I-5), there would be additional congested locations that would delay HOV lane users.

HOV lane calculations are provided in Appendix D

Table 4-45: HOV LOS Summary – Future Year (2040) Conditions - HOV Lane Alternative 5A

Map Ref #	Location		# of Lanes	AM Peak Hour			PM Peak Hour		
				Vol.	Capacity (V/C)	LOS	Vol.	Capacity (V/C)	LOS
1	SR-57 north of I-5 HOV merge	SB	1	***1,975***	***1.04***	***F***	***1,840***	***0.97***	***E***
2	I-5 north of SR-57 HOV merge	SB	1	1,610	0.85	D	1,255	0.66	C
3	I-5 at SR-57 HOV merge	SB	2	***3,585***	***0.94***	***E***	3,095	0.81	D
4	I-5 between SR-57 HOV merge and Main HOV off-ramp	SB	2	***3,585***	***0.94***	***E***	3,095	0.81	D
5	I-5 between Main HOV off-ramp and HOV entrance south of Lincoln overcrossing	SB	2	3,295	0.87	D	2,960	0.78	D
7	I-5 between HOV entrance and Grand HOV on-ramp	SB	2	***3,635***	***0.96***	***E***	3,240	0.85	D
8	I-5 between Grand HOV on-ramp and SR-55 HOV diverge	SB	2	***3,950***	***1.04***	***F***	**3,495**	**0.92**	**E**
9	I-5 south of SR-55 HOV diverge	SB	1	***2,295***	***1.21***	***F***	***2,570***	***1.35***	***F***
11	SR-55 south of I-5 HOV diverge	SB	1	*1,655*	*0.87*	*D*	925	0.49	B
11	SR-55 south of I-5 HOV merge	NB	1	740	0.39	B	1,395	0.73	D
9	I-5 south of SR-55 HOV merge	NB	1	1,595	0.84	D	***2,170***	***1.14***	***F***
8	I-5 between SR-55 HOV merge and Grand HOV off-ramp	NB	2	2,335	0.61	C	***3,565***	***0.94***	***E***
7	I-5 at HOV lane merge (2 to 1 lane)	NB	2	2,000	0.53	C	3,240	0.85	D
6	I-5 between HOV lane merge and HOV lane exit north of Lincoln overcrossing	NB	2	2,000	0.53	C	3,240	0.85	D
5	I-5 between HOV exit and Main HOV off-ramp	NB	2	1,550	0.41	B	2,860	0.75	D
4	I-5 between Main HOV on-ramp and SR-57 diverge	NB	2	1,655	0.44	B	3,345	0.88	D
2	I-5 north of SR-57 diverge	NB	1	905	0.48	B	***2,315***	***1.22***	***F***
1	SR-57 north of I-5 HOV diverge	NB	1	750	0.39	B	1,030	0.54	C

Source: AECOM, 2012.
Notes: **Bold** indicates HOV segment operating at LOS E/F. *Italics* indicate locations where the HOV lane has greater than 1,600 vphpl for 1-lane segment; 1,750 vphpl for 2-lane segment.

Table 4-46: HOV LOS Summary – Future Year (2040) Conditions - HOV Lane Alternative 5B

Map Ref #	Location		# of Lanes	AM Peak Hour			PM Peak Hour		
				Vol.	Capacity (V/C)	LOS	Vol.	Capacity (V/C)	LOS
1	SR-57 north of I-5 HOV merge	SB	1	***1,975***	***1.04***	***F***	***1,840***	***0.97***	***E***
2	I-5 north of SR-57 HOV merge	SB	1	1,320	0.69	C	1,255	0.66	C
3	I-5 at SR-57 HOV merge	SB	2	3,295	0.87	D	2,960	0.78	D
4	I-5 between SR-57 HOV merge and Main HOV off-ramp	SB	2	3,295	0.87	D	2,960	0.78	D
5	I-5 between Main HOV off-ramp and HOV entrance south of Lincoln overcrossing	SB	2	3,295	0.87	D	2,960	0.78	D
7	I-5 between HOV entrance and Grand HOV on-ramp	SB	2	***3,635***	***0.96***	***E***	3,240	0.85	D
8	I-5 between Grand HOV on-ramp and SR-55 HOV diverge	SB	2	***3,950***	***1.04***	***F***	**3,495**	**0.92**	**E**
9	I-5 south of SR-55 HOV diverge	SB	1	***2,295***	***1.21***	***F***	***2,570***	***1.35***	***F***
11	SR-55 south of I-5 HOV diverge	SB	1	*1,655*	*0.87*	*D*	925	0.49	B
11	SR-55 south of I-5 HOV merge	NB	1	740	0.39	B	1,395	0.73	D
9	I-5 south of SR-55 HOV merge	NB	1	1,595	0.84	D	***2,170***	***1.14***	***F***
8	I-5 between SR-55 HOV merge and Grand HOV off-ramp	NB	2	2,335	0.61	C	***3,565***	***0.94***	***E***
7	I-5 at HOV lane merge (2 to 1 lane)	NB	2	2,000	0.53	C	3,240	0.85	D
6	I-5 between HOV lane merge and HOV lane exit north of Lincoln overcrossing	NB	2	2,000	0.53	C	3,240	0.85	D
5	I-5 between HOV exit and Main HOV off-ramp	NB	2	1,550	0.41	B	2,860	0.75	D
4	I-5 between Main HOV on-ramp and SR-57 diverge	NB	2	1,550	0.41	B	2,860	0.75	D
2	I-5 north of SR-57 diverge	NB	1	836	0.44	B	***1,958***	***1.03***	***F***
1	SR-57 north of I-5 HOV diverge	NB	1	750	0.39	B	1,030	0.54	C

Source: AECOM, 2012.
Notes: **Bold** indicates HOV segment operating at LOS E/F. *Italics* indicate locations where the HOV lane has greater than 1,600 vphpl for 1-lane segment; 1,750 vphpl for 2-lane segment.

Although the results for Alternatives 5A and 5B are similar to that of Alternatives 2A and 2B, Alternatives 5A and 5B would perform slightly better with respect to weaving. As noted previously, Alternatives 5A and 5B would not create internal HOV weaving segment that occurs with Alternatives 2A and 2B as both lanes would be on the same side of the concrete barrier. Due to the presence of this barrier in Alternatives 2A and 2B, vehicles in the northbound SR-55 HOV connector would need to weave to exit the HOV lane to access 17th Street, Main Street or SR-22. If these vehicles were to miss this exit, the next available opening would not be available until the SR-57 overcrossing under Alternatives 2A and 2B. Conversely, Alternatives 5A and 5B would provide HOV lane exits to 17th Street, Main Street, and the SR-22 via openings of the concrete barrier, and as such would perform slightly better than Alternatives 2A and 2B by not creating an internal weave within the HOV lanes.

4.6.3 WEAVING PERFORMANCE

With HOV Lane Alternative 5A, conditions at the I-5 Freeway weaving segment would be the same as with No Build, as there would be no change to freeway mainline or Main Street on-ramp volumes with Alternative 5A, as illustrated in Tables 4-47 and 4-48. Weaving calculations can be seen in Appendix E.

Table 4-47: HCM Weaving LOS Summary – Future Year (2040) Conditions – HOV Lane Alternative 5A

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
NB I-5 between Main on-ramp and SR-22 off-ramp	NB	1,650	**>45.0**	**F**	**0.98**	**>45.0**	**F**	**1.02**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 4-48: HDM Weaving LOS Summary – Future Year (2040) Conditions – HOV Lane Alternative 5A

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
NB I-5 between Main on-ramp and SR-22 off-ramp	NB	1,650	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

However, since Alternative 5B would eliminate the Main Street direct HOV on-ramp, there would be an increase in volumes along both the freeway mainline and at the Main Street general-purpose on-ramp. As a result, weaving conditions under Alternative 5B would be slightly worse during both the weekday AM and PM peak hours, as shown in Tables 4-49 and 4-50.

Table 4-49: HCM Weaving LOS Summary – Future Year (2040) Conditions – HOV Lane Alternative 5B

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
NB I-5 between Main on-ramp and SR-22 off-ramp	NB	1,650	**>45.0**	**F**	**0.98**	**>45.0**	**F**	**1.05**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 4-50: HDM Weaving LOS Summary – Future Year (2040) Conditions– HOV Lane Alternative 5B

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
NB I-5 between Main on-ramp and SR-22 off-ramp	NB	1,650	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

4.6.4 INTERSECTION OPERATIONS

A level of service analysis was conducted to evaluate Future Year (2040) Alternatives 5A and 5B intersection operating conditions during the weekday AM and PM peak hours. Table 4-51 summarizes the Future Year (2040) Alternative 5A and 5B levels of service at the study area intersections. Traffic volumes for Future Year (2040) Alternative 5A and 5B are included in Appendix B. Level of service calculation worksheets are included in Appendix F.

With Alternative 5A, the increase in activity along the HOV lanes, due to the second HOV lane in each direction, would result in minor increases in intersection volumes at intersections near the Main Street direct HOV ramps. For Alternative 2B, with the closure of the Main Street I-5 HOV entrance and exit ramps, there would be a redistribution of vehicles in the study area, as high-occupant vehicles would need to find alternative ramps to travel to and from I-5 as discussed in Section 3.3. The redistribution of vehicles can found in Appendix B. For each affected local intersection, minor modifications to signal timing (no geometric changes) were applied where applicable to account for additional vehicles that were redistributed as part of the alternatives. Table 4-51 reflects only the locations where the LOS changes from the No Build (i.e., does not include intersections affected by the Ramp Alternatives). Table 4-51: Future Year (2040) HOV Lane Alternative 5A and 5B LOS Summary

Table 4-51: Intersection LOS Summary – Future Year (2040) Conditions – HOV Lane Alternative 5A and 5B

ID	Intersection	2040 HOV Alt 5A Conditions				2040 HOV Alt 5B Conditions			
		AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS
1	Main / La Veta	20.0	C	26.5	C	20.1	C	27.5	C
2	Main / Memory	17.2	B	21.6	C	17.0	B	21.4	C
3	Main / Edgewood / I-5	40.3	D	48.6	D	35.9	D	41.0	D
4	Broadway / Santa Clara	30.2	C	35.2	D	31.3	C	36.2	D
5	Main / Santa Clara / I-5+	41.6	D	40.5	D	50.8	D	47.3	D
6	Main / 17th+	50.8	D	41.4	D	48.8	D	54.5	D
7	Penn / 17th	11.0	B	14.0	B	11.1	B	14.5	B
8	Santiago / 17th	34.3	C	39.5	D	34.2	C	39.3	D
9	Penn / I-5 SB Ramp	25.3	C	23.2	C	25.3	C	23.3	C

Source: AECOM, 2012
Notes:
+ Minor intersection signal timing adjustments made to account for additional vehicles that were redistributed as part of HOV Lane Alternatives 5A and 5B.
[1] Delay is shown in seconds per vehicle. For signalized locations, delay reported is average delay of all approaches.

As shown in Table 4-51, all of the study area intersections affected by HOV Lane Alternative 5A and 5B will continue to operate acceptably (LOS D or better) under Future Year (2040) conditions.

4.6.5 RAMP QUEUING

The queuing analysis results of the Opening Year (2040) HOV Lane Alternatives 5A and 5B during the weekday AM and PM peak hours are presented in Table 4-52. As with No Build conditions, queues that would develop under the HOV Lane Alternatives 5A and 5B could be accommodated within the available storage distance. HOV Lane Alternative 5A would have queue lengths almost identical to No Build conditions. HOV Lane Alternative 5B would have increased queue lengths at the off-ramps due to more mixed flow vehicles exiting at these locations from the elimination of the Main Street HOV ramps. Queue length calculations can be found in Appendix G.

Table 4-52: Ramp Queuing Summary – Future Year (2040) Conditions – HOV Lane Alternatives 5A and 5B

Map Ref #	Off-Ramp Location	Controlling Intersection Approach	Available Storage Length (feet)	Percentile	2040 5A		2040 5B	
					AM Queue Length (feet)	PM Queue Length (feet)	AM Queue Length (feet)	PM Queue Length (feet)
3	Main / Edgewood / I-5	Northwest	1,357	50th	432	161	432	161
				95th	664	270	664	266
3	Main / Edgewood / I-5 (HOV off-ramp)	Eastbound	1,353	50th	66	30	82	157
				95th	250	135	239	333
5	Main / Santa Clara / I-5	Southeast	1,060	50th	246	321	344	358
				95th	486	513	601	555
22	Grand / Santa Ana (HOV off-ramp)	Westbound	1,538	50th	104	86	104	86
				95th	151	131	151	131

Source: AECOM, 2012.

5.0 RAMP ALTERNATIVE ANALYSIS

This section discusses Ramp Alternatives A and B locations in the study area under Existing (2011), Opening Year (2018), and Future Year (2040) Conditions in the study area. For the purpose of this traffic report, the HOV Lane Alternatives and the Ramp Alternatives have been evaluated separately as two distinct project elements. Since the second northbound and southbound HOV lanes will be located over 0.5 miles north of the current First Street entrance ramp to southbound I-5, there would no overlap of traffic impacts or changes to traffic volumes that could affect conditions to points south. The Ramp Alternatives would not affect HOV operations; therefore, an HOV analysis was not included in this section.

5.1 OPENING YEAR (2018) NO BUILD

5.1.1 FREEWAY MAINLINE PERFORMANCE

As shown in Table 5-1, during the weekday AM and PM peak hours, each of the four study segments on the I-5 Freeway are forecast to operate at LOS E or F during Opening Year (2018) No Build conditions, except in the northbound direction just south of the First/Fourth Street off-ramp in the PM peak hour. HCS development worksheets can be found in Appendix C.

Table 5-1: Freeway LOS Summary – Opening Year (2018) Conditions – No Build

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			ML	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**10,330**	**40.1**	**E**	**10,285**	**39.7**	**E**
10	I-5 between First on-ramp and SR-55 off-ramp	SB	5	1	**10,800**	**>45.0**	**F**	**10,955**	**>45.0**	**F**
10	I-5 between SR-55 on-ramp and First/Fourth off-ramp	NB	5	1	**12,095**	**>45.0**	**F**	9,620	34.9	D
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**11,790**	**>45.0**	**F**	**9,754**	**35.7**	**E**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS..
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

5.1.2 WEAVING PERFORMANCE

Under Opening Year (2018) No Build conditions, the weaving section on the I-5 Freeway southbound between the First Street on-ramp and the SR-55 exit would operate at LOS F during both the weekday AM and PM peak hours. Overall, there would be an increase in density and weaving segment V/C ratio over Existing conditions due to the general increase in volumes in the area, as shown in Tables 5-2 and 5-3. Weaving calculations can be seen in Appendix E.

Table 5-2: HCM Weaving LOS Summary – Opening Year (2018) Conditions – No Build

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	1,555	**>45.0**	**F**	**1.18**	**>45.0**	**F**	**1.16**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 5-3: HDM Weaving LOS Summary – Opening Year (2018) Conditions – No Build

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	1,555	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

5.1.3 INTERSECTION OPERATIONS

A level of service analysis was conducted to evaluate Opening Year (2018) No Build intersection operating conditions during the weekday AM and PM peak hours. Table 5-4 summarizes the Opening Year (2018) No Build levels of service at the study area intersections. Level of service calculation worksheets are included in Appendix F.

Table 5-4: Intersection LOS Summary – Opening Year (2018) Conditions – No Build

ID	Intersection	AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS
10	Main / 4th	11.3	B	12.0	B
11	Grand / 4th	33.4	C	42.2	D
12	I-5 SB Ramp / 4th	11.4	B	15.1	B
13	I-5 NB Ramp / 4th	8.9	A	18.1	B
14	Cabrillo / 4th	28.2	C	32.4	C
15	Tustin / 4th	31.5	C	41.5	D
16	Main / 1st	41.0	D	36.9	D
17	Grand / 1st	**61.9**	**E**	**71.5**	**E**
18	I-5 SB Ramp / 1st	8.2	A	10.2	B
19	Cabrillo / 1st	25.8	C	26.1	C
20	Tustin / 1st	15.9	B	16.7	B
21	I-5 Ramp / Santa Ana	19.7	B	**57.7**	**E**
22	Grand / Santa Ana	27.6	C	35.2	D
24	Mabury / Elk / 1st	27.8	C	39.4	D
25	Lyon / 1st	19.3	B	18.0	B

ID	Intersection	AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS
26	Cabrillo / State Fund	4.5	A	6.0	A
27	Cabrillo / Xerox Center	4.4	A	7.1	A
28	Golden Circle / 4th	8.2	A	10.1	B
29	Golden Circle / 1st	7.5	A	7.7	A
30	SR-55 SB Ramps / 4th	**>80.0**	**F**	20.2	C
31	SR-55 NB Ramps / 4th	17.8	B	36.6	D

Source: AECOM, 2012

Notes:

Bold indicates intersection operating at unacceptable LOS.

[1] Delay is shown in seconds per vehicle. For signalized locations, delay reported is average delay of all approaches.

As shown in Table 5-4, all study area intersections operate acceptably (LOS D or better) under Opening Year (2018) No Build conditions, with the exception of the following locations:

- Grand Avenue/First Street: LOS E in the AM and PM peak hours. LOS E conditions at this location would be a result of the general increase in traffic along both streets by Year 2018, especially at the northbound and southbound approaches.

- I-5 SB Ramp/Santa Ana Boulevard: LOS E in the PM peak hour. During the weekday PM peak hour, the increase in traffic destined to I-5 southbound from eastbound Santa Ana Boulevard would cause this location to worsen to LOS E. In particular, the eastbound left-turn volume is projected to exceed the capacity of the provided left-turn pockets.

- SR-55 SB Ramps/Fourth Street: LOS F in the AM peak hour. At this location, the over-capacity conditions for eastbound and westbound Fourth Street under Existing conditions would slightly worsen due to the increase in volumes under the Opening Year (2018) scenario.

5.1.4 RAMP QUEUING

The queuing analysis results of the Opening Year (2018) No Build scenario during the weekday AM and PM peak hours are presented in Table 5-5. Queue length calculations can be found in Appendix G. As with Existing conditions, queues that would develop under the No Build Alternative could be accommodated within the available storage distance.

Table 5-5: Ramp Queue Summary – Opening Year (2018) Conditions – No Build

ID	Off-Ramp Location	Controlling Intersection Approach	Available Storage Length (feet)	Percentile	AM Queue Length (feet)	PM Queue Length (feet)
12	I-5 SB Ramp / 4th	Southbound	1,000	50th	87	113
				95th	192	182
13	I-5 NB Ramp / 4th	Northbound	1,080	50th	39	112
				95th	143	239
24	Mabury / Elk / 1st (I-5 Northbound (horseshoe ramp)	Southbound	1,280	50th	432	322
				95th	746	684

Source: AECOM, 2012.

5.2 OPENING YEAR (2018) RAMP ALTERNATIVES A AND B

5.2.1 FREEWAY MAINLINE PERFORMANCE

As shown in Table 5-6 and Table 5-7, during the weekday AM and PM peak hours, each of the four basic segments on the I-5 Freeway for Ramp Alternatives A are forecast to operate at LOS E or F, except in the northbound direction just south of the First/Fourth Street off-ramp in the PM peak hour under Ramp Alternative A, where it would operate at LOS D. In general, there would be minimal changes to the I-5 Freeway volumes with Ramp Alternatives A and B as compared to the No Build scenario, as the analysis for both Alternatives account for a minor rerouting of vehicles from I-5 and the study ramps to SR-55 and its on- and off-ramps at Fourth Street. HCS development worksheets can be found in Appendix C.

Table 5-6: Freeway LOS Summary – Opening Year (2018) Conditions – Ramp Alternative A

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			ML	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**10,330**	**40.1**	**E**	**10,285**	**39.7**	**E**
10	I-5 between First on-ramp and SR-55 off-ramp	SB	5	1	**10,750**	**44.1**	**E**	**10,885**	**>45.0**	**F**
10	I-5 between SR-55 on-ramp and First/Fourth off-ramp	NB	5	1	**12,146**	**>45.0**	**F**	**9,647**	**35.0**	**E**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**11,892**	**>45.0**	**F**	**9,808**	**36.1**	**E**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS..
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

Table 5-7: Freeway LOS Summary – Opening Year (2018) Conditions – Ramp Alternative B

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			ML	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**10,330**	**40.1**	**E**	**10,285**	**39.7**	**E**
10	I-5 between First on-ramp and SR-55 off-ramp	SB	5	1	**10,790**	**44.5**	**E**	**10,934**	**>45.0**	**F**
10	I-5 between SR-55 on-ramp and First/Fourth off-ramp	NB	5	1	**12,095**	**>45.0**	**F**	9,620	34.9	D
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**11,790**	**>45.0**	**F**	**9,754**	**35.7**	**E**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS..
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

5.2.2 WEAVING PERFORMANCE

As compared to the Opening Year (2018) No Build conditions, operations of the weaving segment with HOV Lane Alternative A would improve due to the relocation of the southbound on-ramp about 1,050 feet to the north. Although the entire weaving section would continue to operate at LOS F as shown in Tables 5-8 and 5-9, V/C ratio would be slightly reduced (by about 0.01). Although the decrease in V/C would be relatively minimal during both the weekday AM and PM peak hours, even small increases in capacity can result in improved operations and safety conditions by reducing density and increasing speeds. Weaving calculations can be seen in Appendix E.

Table 5-8: HCM Weaving LOS Summary – Opening Year (2018) Conditions – Ramp Alternative A

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	2,605	**>45.0**	**F**	**1.17**	**>45.0**	**F**	**1.15**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 5-9: HDM Weaving LOS Summary – Opening Year (2018) Conditions – Ramp Alternative A

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	2,605	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

As compared to the Opening Year (2018) No Build conditions, operations of the weaving segment with HOV Lane Alternative B would also improve due to the relocation of the southbound on-ramp about 740 feet to the north. Although the entire weaving section would continue to operate at LOS F as shown in Table 5-10, the weaving segment V/C ratio would be slightly reduced, although by a smaller reduction than with HOV Lane Alterative A using the HCM methodology. Table 5-11 shows the results using the HDM methodology.

Table 5-10: HCM Weaving LOS Summary – Opening Year (2018) Conditions – Ramp Alternative B

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	2,295	**>45.0**	**F**	**1.17**	**>45.0**	**F**	**1.16**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 5-11: HDM Weaving LOS Summary – Opening Year (2018) Conditions – Ramp Alternative B

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	2,295	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

Both Ramp Alternatives would meet the minimum weaving length standard as described in the Highway Design Manual (HDM) Section 504.7. Section 504.7 of the HDM states that the minimum weaving length, measured as shown on Figures 504.2A and 504.2B shall be 2,000 feet in urban areas, 5,000 feet in rural areas, and 5,000 feet between freeway-to-freeway interchanges and other interchanges.

5.2.3 INTERSECTION OPERATIONS

A level of service analysis was conducted to evaluate Opening Year (2018) Ramp Alternatives A and B intersection operating conditions during the weekday AM and PM peak hours. It should be noted that for each affected local intersection, minor modifications to signal timing (no geometric changes) were applied where applicable to account for additional vehicles that were redistributed as part of the alternatives. Table 5-12 summarizes the Opening Year (2018) Ramp Alternatives A and B levels of service at the study area intersections. Traffic volumes for Opening Year (2018) Ramp Alternatives A and B are included in Appendix B. Level of service calculation worksheets are included in Appendix F.

Table 5-12: Intersection LOS Summary – Opening Year (2018) Conditions – Ramp Alternatives A and B

ID	Intersection	2018 Ramp Alt A Conditions				2018 Ramp Alt B Conditions			
		AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS
10	Main / 4th	11.6	B	12.0	B	11.3	B	12.0	B
11	Grand / 4th+	49.0	D	54.0	D	32.7	C	41.3	D
12	I-5 SB Ramp / 4th	19.9	B	18.4	B	10.7	B	14.6	B
13	I-5 NB Ramp / 4th	8.7	A	21.8	C	8.8	A	17.8	B
14	Cabrillo / 4th	28.3	C	32.3	C	28.3	C	33.8	C
15	Tustin / 4th	32.1	C	46.1	D	31.5	C	41.5	D
16	Main / 1st	52.2	D	36.0	D	41.0	D	36.9	D
17	Grand / 1st+	**65.8**	**E**	**76.1**	**E**	**63.7**	**E**	**73.5**	**E**
18	I-5 SB Ramp / 1st	Ramp removed				Ramp removed			
19	Cabrillo / 1st	26.3	C	26.6	C	30.7	C	32.4	C
20	Tustin / 1st	15.9	B	16.9	B	15.9	B	16.7	B
21	I-5 Ramp / Santa Ana	19.7	B	**57.7**	**E**	19.7	B	**57.7**	**E**
22	Grand / Santa Ana	27.6	C	35.2	D	27.6	C	35.2	D
24	Mabury / Elk / 1st	17.7	B	30.1	C	41.7	D	30.3	C
25	Lyon / 1st	31.8	C	18.9	B	16.5	B	17.3	B
26	Cabrillo / State Fund	4.4	A	6.6	A	4.3	A	6.1	A
27	Cabrillo / Xerox Center	4.4	A	9.3	A	4.5	A	7.3	A
28	Golden Circle / 4th	8.1	A	10.2	B	8.3	A	10.1	B
29	Golden Circle / 1st	8.9	A	8.7	A	7.5	A	7.7	A
30	SR-55 SB Ramps / 4th+	**> 80.0**	**F**	20.7	C	**>80.0**	**F**	20.4	C
31	SR-55 NB Ramps / 4th+	18.4	B	37.7	D	17.8	B	36.6	D

Source: AECOM, 2012

Notes:
+ Minor intersection signal timing adjustments made to account for additional vehicles that were redistributed as part of Ramp Alternatives A and B.
Bold indicates intersection continues to operate at unacceptable LOS
[1] Delay is shown in seconds per vehicle. For signalized locations, delay reported is average delay of all approaches.

As shown in Table 5-12, all of the study area intersections affected by the Ramp Alternatives will continue to operate acceptably (LOS D or better) under Opening Year (2018) Ramp Alternative A and Ramp Alternative B conditions, and operations at the three locations that would operate at LOS E/F would not change from under Opening Year (2018) No Build conditions.[5]

[5] Although Ramp Alternative 2 would require the elimination of the existing eastbound and westbound left-turns at the intersection of First Street/Lyon Street, the rerouting of vehicles to the adjacent Wright Street intersection (which would be signalized) would not affect intersection operating conditions or substantially degrade local access and circulation.

5.2.4 RAMP QUEUING

The queuing analysis results of the Opening Year (2018) Ramp Alternatives A and B during the weekday AM and PM peak hours are presented in Table 5-13. As with No Build conditions, queues that would develop under the Ramp Alternatives A and B could be accommodated within the available storage distance. Ramp Alternative A would have queue lengths longer than No Build conditions, as all northbound off-ramp vehicles would use the I-5 northbound exit to Fourth Street instead of some vehicles using the horseshoe ramp to First Street which would be eliminated. For Ramp Alternative A, 95th percentile queues at the I-5.northbound off-ramp at Fourth Street would not extend to the end of the off-ramp during the weekday AM and PM peak hours. With Ramp Alternative B, queues at this ramp would not substantially change, as the horseshoe ramp would remain with this alternative. Queue length calculations can be found in Appendix G.

Table 5-13: Ramp Queue Summary – Opening Year (2018) Conditions – Ramp Alternative A and B

ID	Off-Ramp Location	Controlling Intersection Approach	Available Storage Length (feet)	Percentile	2018 Ramp A		2018 Ramp B	
					AM Queue Length (feet)	PM Queue Length (feet)	AM Queue Length (feet)	PM Queue Length (feet)
12	I-5 SB Ramp / 4th	Southbound	1,000	50th	133	84	72	113
				95th	234	151	157	182
13	I-5 NB Ramp / 4th	Northbound	1,080	50th	53	183	36	112
				95th	109	398	138	239
24	Mabury / Elk / 1st (I-5 Northbound (Loop ramp)	Southbound	1,280	50th	--	--	240	116
				95th	--	--	496	324

Source: AECOM, 2012.

5.3 FUTURE YEAR (2040) NO BUILD

5.3.1 FREEWAY MAINLINE PERFORMANCE

As shown in Table 5-14, during the weekday AM and PM peak hours, each of the four basic segments on the I-5 Freeway are forecasted to operate at LOS E or F during Future Year (2040) No Build conditions, with higher volumes and increased density as compared to Opening Year (2018) conditions. HCS development worksheets can be found in Appendix C.

Table 5-14: Freeway LOS Summary – Future Year (2040) Conditions – No Build

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			ML	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	**12,025**	**>45.0**	**F**	**11,490**	**>45.0**	**F**
10	I-5 between First on-ramp and SR-55 off-ramp	SB	5	1	**12,545**	**>45.0**	**F**	**12,160**	**>45.0**	**F**
10	I-5 between SR-55 on-ramp and First/Fourth off-ramp	NB	5	1	**12,760**	**>45.0**	**F**	**10,560**	**42.2**	**E**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	**12,433**	**>45.0**	**F**	**10,629**	**42.8**	**E**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS..
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

5.3.2 WEAVING PERFORMANCE

As shown in Table 5-15, under Future Year (2040) No Build conditions, the weaving section on the I-5 Freeway southbound between the First Street on-ramp and the SR-55 exit would operate at LOS F during both the weekday AM and PM peak hours. There would be an increase in density and weaving segment V/C ratio over Existing and Opening Year (2018) conditions due to the general increase in volumes in the area. Weaving calculations can be seen in Appendix E.

Table 5-15: HCM Weaving LOS Summary – Future Year (2040) Conditions – No Build

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	1,555	**>45.0**	**F**	**1.23**	**>45.0**	**F**	**1.18**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 5-16 shows the results using the HDM methodology. The calculation worksheets are included in Appendix E. As the table indicates, the weave section would operate at LOS F using the HDM methodology.

Table 5-16: HDM Weaving LOS Summary – Future Year (2040) Conditions – No Build

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	1,555	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

5.3.3 INTERSECTION OPERATIONS

A level of service analysis was conducted to evaluate Future Year (2040) No Build intersection operating conditions during the weekday AM and PM peak hours. Table 5-17 summarizes the Future Year (2040) No Build levels of service at the study area intersections. Level of service calculation worksheets are included in Appendix E.

Table 5-17: Intersection LOS Summary - Future Year (2040) Conditions – No Build

ID	Intersection	AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS
10	Main / 4th	11.3	B	12.0	B
11	Grand / 4th	34.0	C	43.7	D
12	I-5 SB Ramp / 4th	11.2	B	15.1	B
13	I-5 NB Ramp / 4th	9.0	A	18.5	B
14	Cabrillo / 4th	29.4	C	35.4	D
15	Tustin / 4th	42.0	D	44.5	D
16	Main / 1st	45.0	D	40.7	D
17	Grand / 1st	**71.5**	**E**	**>80.0**	**F**
18	I-5 SB Ramp / 1st	8.4	A	10.4	B
19	Cabrillo / 1st	26.6	C	27.7	C
20	Tustin / 1st	17.8	B	17.3	B
21	I-5 Ramp / Santa Ana	20.6	C	**62.1**	**E**
22	Grand / Santa Ana	27.4	C	36.5	D
24	Mabury / Elk / 1st	28.8	C	43.3	D
25	Lyon / 1st	19.6	B	18.8	B
26	Cabrillo / State Fund	4.5	A	5.9	A
27	Cabrillo / Xerox Center	4.3	A	7.0	A
28	Golden Circle / 4th	8.0	A	10.3	B
29	Golden Circle / 1st	7.6	A	7.9	A
30	SR-55 SB Ramps / 4th	**>80.0**	**F**	24.2	C
31	SR-55 NB Ramps / 4th	15.9	B	48.4	D

Source: AECOM, 2012

Notes:

Bold indicates intersection operating at unacceptable LOS.

[1] Delay is shown in seconds per vehicle. For signalized locations, delay reported is average delay of all approaches.

As shown in Table 5-17, all study area intersections would operate acceptably (LOS D or better) under Future Year (2040) No Build conditions, with the exception of the following intersections:

- Grand Avenue/First Street: LOS E in the AM peak hour, LOS F in the PM peak hour. The LOS E/F conditions at this location would be a result of the general

increase in traffic along both streets by Year 2040, especially in the northbound and southbound.

- I-5 SB Ramp/Santa Ana Boulevard: LOS E in the PM peak hour. During the weekday PM peak hour, the continued increase in traffic destined to I-5 southbound from eastbound Santa Ana Boulevard would cause this location to operate at LOS E. In particular, the eastbound left-turn volume would exceed the capacity of the left-turn pockets and thus create operate at LOS F conditions.

- SR-55 SB Ramps/Fourth Street: LOS F in the AM peak hour. At this location, the over-capacity conditions for eastbound and westbound Fourth Street under Existing conditions would continue to worsen due to the increase in volumes under the Future Year (2040) scenario, with the westbound left-turn movement spilling-back past the available left-turn pocket.

5.3.4 RAMP QUEUING

The queuing analysis results of the Future Year (2040) No Build scenario during the weekday AM and PM peak hours are presented in Table 5-14. Queue length calculations can be found in Appendix G. Table 5-18 summarizes the Future Year (2040) No Build ramp queues. As with Existing and Opening Year (2018) conditions, queues that would develop under the Future Year (2040) No Build Alternative could be accommodated within the available storage distance.

Table 5-18: Ramp Queue Summary – Future Year (2040) Conditions – No Build

ID	Off-Ramp Location	Controlling Intersection Approach	Available Storage Length (feet)	Percentile	AM Queue Length (feet)	PM Queue Length (feet)
12	I-5 SB Ramp / 4th	Southbound	1,000	50th	84	109
				95th	186	177
13	I-5 NB Ramp / 4th	Northbound	1,080	50th	40	137
				95th	146	364
24	Mabury / Elk / 1st (I-5 Northbound (Loop ramp)	Southbound	1,280	50th	445	326
				95th	763	693

Source: AECOM, 2012.

5.4 FUTURE YEAR (2040) RAMP ALTERNATIVES A AND B

5.4.1 FREEWAY MAINLINE PERFORMANCE

As shown in Tables 5-19 and Table 5-20, during the weekday AM peak hour, each of the four basic segments on the I-5 Freeway for both Ramp Alternatives A and B are forecast to operate at unsatisfactory LOS E or F. In general, there would be minimal changes to the I-5 Freeway volumes with Ramp Alternatives A and B as compared to the No Build scenario, as the analysis for both Alternatives account for a minor rerouting of vehicles

from I-5 and the study ramps to SR-55 and its on- and off-ramps at Fourth Street. HCS development worksheets can be found in Appendix C.

Table 5-19: Freeway LOS Summary – Future Year (2040) Conditions – Alternative A

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			ML	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	12,025	**>45.0**	**F**	**11,490**	**>45.0**	**F**
10	I-5 between First on-ramp and SR-55 off-ramp	SB	5	1	12,495	**>45.0**	**F**	**12,090**	**>45.0**	**F**
10	I-5 between SR-55 on-ramp and First/Fourth off-ramp	NB	5	1	12,813	**>45.0**	**F**	**10,587**	**42.4**	**E**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	12,537	**>45.0**	**F**	**10,683**	**43.4**	**E**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

Table 5-20: Freeway LOS Summary – Future Year (2040) Conditions – Alternative B

Map Ref #	Locations		Lanes		AM Peak Hour			PM Peak Hour		
			ML	Aux	Volume	Density[1]	LOS	Volume	Density[1]	LOS
8	I-5 between Grand on-ramp and Fourth off-ramp	SB	5	1	12,025	**>45.0**	**F**	**11,490**	**>45.0**	**F**
10	I-5 between First on-ramp and SR-55 off-ramp	SB	5	1	12,534	**>45.0**	**F**	**12,138**	**>45.0**	**F**
10	I-5 between SR-55 on-ramp and First/Fourth off-ramp	NB	5	1	12,760	**>45.0**	**F**	**10,560**	**42.2**	**E**
8	I-5 between Fourth on-ramp and Grand off-ramp	NB	5	1	12,433	**>45.0**	**F**	**10,629**	**42.8**	**E**

Source: AECOM, 2012.
Notes: **Bold** indicates freeway segment operating at unacceptable LOS..
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)

5.4.2 WEAVING PERFORMANCE

As compared to the Future Year (2040) No Build conditions, operations of the weaving segment with HOV Lane Alternative A would improve due to the relocation of the southbound on-ramp about 1,050 feet to the north as shown in Tables 5-21 and 5-22. Although the entire weaving section would continue to operate at LOS F, weaving segment V/C ratio would be reduced by 0.01. Although the decrease in V/C would be relatively minimal during both the weekday AM and PM peak hours, even small increases in capacity can result in improved operations and safety conditions by reducing density and increasing speeds. Weaving calculations can be seen in Appendix E.

Table 5-21: HCM Weaving LOS Summary – Future Year (2040) Conditions – Ramp Alternative A

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	2,605	**>45.0**	**F**	**1.22**	**>45.0**	**F**	**1.17**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 5-22: HDM Weaving LOS Summary – Future Year (2040) Conditions – Ramp Alternative A

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	2,605	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

As compared to the Future Year (2040) No Build conditions, operations of the weaving segment with HOV Lane Alternative B would improve due to the relocation of the southbound on-ramp about 740 feet to the north as shown in Tables 5-23 and 5-24. Although the entire weaving section would continue to operate at LOS F, the density and weaving segment V/C ratio would not noticeably improve with HOV Lane Alterative B.

Table 5-23: HCM Weaving LOS Summary – Future Year (2040) Conditions – Ramp Alternative B

Location		Weave Distance	AM Peak Hour			PM Peak Hour		
			Density[1]	LOS	V/C[2]	Density[1]	LOS	V/C[2]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	2,295	**>45.0**	**F**	**1.23**	**>45.0**	**F**	**1.18**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] Density is shown in passenger cars / miles / lane (pc/mi/ln)
[2] V/C = volume/capacity, V/C is shown for informational purposes only, and is not included in the LOS determination

Table 5-24: HDM Weaving LOS Summary – Future Year (2040) Conditions – Ramp Alternative B

Location		Weave Distance	AM Peak Hour	PM Peak Hour
			LOS[1]	LOS[1]
SB I-5 between 1st on-ramp and SR-55 off-ramp	SB	2,295	**F**	**F**

Source: AECOM, 2012.
Notes: **Bold** indicates weaving segment operating at unacceptable LOS.
[1] *Highway Design Manual* (Chapter 500, Figure 504.7A, Leisch Curves)

5.4.3 INTERSECTION OPERATIONS

A level of service analysis was conducted to evaluate Future Year (2040) Ramp Alternatives A and B intersection operating conditions during the weekday AM and PM peak hours. It should be noted that for each affected local intersection, minor modifications to signal timing (no geometric changes) were applied where applicable to account for additional vehicles that were redistributed as part of the alternatives. Table 5-25 summarizes the Future Year (2040) Ramp Alternatives A and B levels of service at the study area intersections. Traffic volumes for Future Year (2040) Ramp Alternatives A and B are included in Appendix B. Level of service calculation worksheets are included in Appendix F.

Table 5-25: Intersection LOS Summary – Future Year (2040) Conditions – Ramp Alternatives A and B

ID	Intersection	2040 Ramp Alt A Conditions				2040 Ramp Alt B Conditions			
		AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
		Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS	Delay[1]	LOS
10	Main / 4th	11.9	B	12.1	B	11.5	B	12.1	B
11	Grand / 4th+	50.3	D	54.8	D	34.2	C	45.6	D
12	I-5 SB Ramp / 4th	20.7	C	18.8	B	10.9	B	14.5	B
13	I-5 NB Ramp / 4th	8.9	A	25.8	C	8.9	A	18.6	B
14	Cabrillo / 4th	31.1	C	37..7	D	30.3	C	39.2	D
15	Tustin / 4th	46.7	D	49.0	D	45.4	D	46.1	D
16	Main / 1st	46.6	D	41.6	D	49.6	D	44.6	D
17	Grand / 1st+	**74.3**	**E**	**>80.0**	**F**	**73.2**	**E**	**>80.0**	**F**
18	I-5 SB Ramp / 1st	Ramp removed				Ramp removed			
19	Cabrillo / 1st	28.6	C	29.9	C	35.4	D	34.4	C
20	Tustin / 1st	18.2	B	17.8	B	18.1	B	17.5	B
21	I-5 Ramp / Santa Ana	20.9	C	**>80.0**	**F**	20.9	C	**80.6**	**F**
22	Grand / Santa Ana	27.8	C	37.9	D	27.8	C	37.9	D
24	Mabury / Elk / 1st	29.8	C	21.4	C	45.7	D	31.2	C
25	Lyon / 1st	30.3	C	28.7	C	16.6	B	17.4	B
26	Cabrillo / State Fund	4.5	A	6.0	A	4.2	A	6.1	A
27	Cabrillo / Xerox Center	4.2	A	9.9	A	4.4	A	7.3	A
28	Golden Circle / 4th	8.8	A	11.8	B	8.1	A	11.6	B
29	Golden Circle / 1st	9.1	A	8.8	A	7.7	A	8.8	A
30	SR-55 SB Ramps / 4th+	**>80.0**	**F**	26.6	C	**>80.0**	**F**	26.3	C
31	SR-55 NB Ramps / 4th+	17.5	B	51.5	D	16.9	B	49.2	D

Source: AECOM, 2012

Notes:
+ Minor intersection signal timing adjustments made to account for additional vehicles that were redistributed as part of Ramp Alternatives A and B.

Bold indicates intersection operating at unacceptable LOS.

[1] Delay is shown in seconds per vehicle. For signalized locations, delay reported is average delay of all approaches.

As shown in Table 5-25, all of the study area intersections affected by the Ramp Alternatives will continue to operate acceptably (LOS D or better) under Future Year (2040) Ramp Alternative A and Ramp Alternative B conditions with the exception of three locations. These locations, however, are not considered impacts as they operate unacceptably under Future Year (2040) No Build conditions. The addition vehicles due to the redistribution due to the two ramp configurations would not cause any substantial increase in delay. [6]

5.4.4 RAMP QUEUING

The queuing analysis results of the Ramp Alternatives A and B during the weekday AM and PM peak hours are presented in Table 5-26. As with No Build conditions, queues that would develop under the Ramp Alternatives A and B could be accommodated within the available storage distance. Ramp Alternative A would have queue lengths longer than No Build conditions. This increase in queue distances would be due to the elimination of the horseshoe ramp for the alternative, thereby requiring all exiting vehicles to travel through the intersection with Fourth Street. Queue length calculations can be found in Appendix G.

Table 5-26: Ramp Queue Summary – Future Year (2040) Conditions – Ramp Alternative A and B

ID	Off-Ramp Location	Controlling Intersection Approach	Available Storage Length (feet)	Percentile	2040 Ramp A		2040 Ramp B	
					AM Queue Length (feet)	PM Queue Length (feet)	AM Queue Length (feet)	PM Queue Length (feet)
12	I-5 SB Ramp / 4th	Southbound	1,000	50th	141	111	78	113
				95th	245	214	168	182
13	I-5 NB Ramp / 4th	Northbound	1,080	50th	61	205	41	134
				95th	116	414	149	302
24	Mabury / Elk / 1st (I-5 Northbound (Loop ramp)	Southbound	1,280	50th	--	--	259	105
				95th	--	--	533	255

Source: AECOM, 2012.

[6] Although Ramp Alternative 2 would require the elimination of the existing eastbound and westbound left-turns at the intersection of First Street/Lyon Street, the rerouting of vehicles to the adjacent Wright Street intersection (which would be signalized) would not affect intersection operating conditions or substantially degrade local access and circulation.

6.0 CONCLUSIONS

The I-5 from SR-55 to SR-57 HOV Improvement Project provides much-needed capacity for high occupancy vehicles on Interstate 5. This TAR evaluated four HOV lane alternatives, HOV Lane Alternatives 2A, 2B, 5A, and 5B. In addition, the project also analyzed two ramp alternatives, Ramp Alternative A and B, for potentially reconfiguring the I-5 First Street and Fourth Street on- and off-ramps.

According to Caltrans' SAFETEA-LU *Federal Determination Report: ILEV/Hybrids on HOV Facilities in California,* the HOV lane northbound and southbound along the I-5 between the SR-55 and SR-57 are considered degraded facilities during one or both of the AM and PM peak hours.

Overall, provision of the HOV Lane Alternatives would result in the elimination of critical bottlenecks on the HOV network, thereby increasing HOV activity and facilitating HOV throughput. However, the future demand for the HOV facilities by Year 2040 would be higher than the provided capacity with Alternatives 2A, 2B, 5A, and 5B, resulting in new constraints points and overloaded facilities (especially to the north and south of the project's two-lane segments).

Both Ramp Alternatives would improve the weave density, with Ramp Alternative A performing slightly better due to the longer weaving distance available with this alternative. However, the magnitude of improvements is limited due to the overall over-capacity conditions on the I-5 mainline and within the weave area.

For both the HOV Lane Alternatives and the Ramp Alternatives, there would be a redistribution of local traffic through the nearby streets and intersections. However, the project would not significantly impact any of the analyzed intersections, and all locations would not be negatively affected by the proposed HOV lane, elimination of the Main Street direct HOV ramps, and the First Street on-ramp changes.

HOV Lane Alternatives

In the Opening Year (2018), and Future Year (2040) No Build scenarios, major north-south I-5 bottlenecks were forecast to severely constrain the amount of vehicles able to utilize the I-5 HOV lanes between the SR-55 and SR-57 freeways, ultimately contributing to congestion on the HOV lane. Provision of any of the HOV Lane Alternatives, 2A, 2B, 5A, and 5B, eliminates these capacity constraints, thereby attracting additional HOV users to the study segment.

Since the mainline volumes are not substantially affected by the project, there would be only minor changes in queues and weaving along I-5. In addition, there would be minor changes to local intersection volumes due to increases in HOV volumes. Overall, HOV Lane Alternatives 2A/2B and 5A/5B would be almost identical operationally, with the exception of the minor internal weaving segment that occurs as part of Alternatives 2A/2B. Alternatives 2A and 2B would introduce a new weaving segment when compared to conditions under Existing conditions and with Alternatives 5A and 5B. The presence of a barrier in Alternatives 2A and 2B beginning south of the Lincoln Avenue overcrossing

creates a new weave segment between HOV vehicles originating from the northbound SR-55 HOV connector and those destined to 17th Street, Main Street or SR-22 via the northbound I-5 HOV lane. Based on a review of local trip destinations, it is anticipated that only minimal portion of peak hour SR-55 HOV vehicles would weave to access the HOV lane exit. Given the distance available to exit (over 1,500 feet), it is anticipated that this weaving activity would not disrupt HOV lane operations. It should be noted that if HOV vehicles destined to 17th Street, Main Street or SR-22 miss the exit at this location, the next available exit would not be until the SR-57 overcrossing.

HOV Lane Alternatives 2B and 5B would result in additional rerouting of vehicles on local streets and slight worsening in mainline operations and local intersections due to the elimination of the Main Street direct HOV ramps. However, these changes would not impact any of the study area intersections, as evidenced by the intersection level of service analysis.

As implementation of the HOV Lane Alternatives would eliminate the current and future bottleneck locations at the HOV lanes (southbound at the I-5/SR-57 merge and northbound at the I-5/SR-55 merge), it would increase overall capacity of the HOV lanes in the study area. Under Year 2018 conditions, there would be an increase in HOV lane volumes of up to 1,070 vph in the AM peak hour and 1,025 vph in the PM peak hour for Alternatives 2A/5A, and up to 1,030 vph in the AM peak hour and 1,010 vph in the PM peak hour for Alternatives 2B/5B. Under Year 2040 conditions, there would be an increase of up to 2,035 vph in the AM peak hour and 1,545 vph in the PM peak hour for Alternatives 2A/5A, and up to 1,900 vph in the AM peak hour and 1,475 vph in the PM peak hour for Alternatives 2B/5B. This increase in HOV lane usage would result in benefits to the system and improve conditions for all users.

However, under Future Year (2040) conditions, the increased demand for HOV facilities would result in new bottleneck and over-capacity conditions, primarily at intermediate access points (such as at the Grand Avenue direct HOV lane entrance to southbound I-5) and where the two-lane segment narrows down to one lane along I-5 at the SR-57 and SR-55 HOV lane diverges.

With Alternatives 2B and 5B, the direct HOV entrance and exit ramps at Main Street would be eliminated. In Year 2018, the combined removal of these ramps would affect about 245 vehicles in the weekday AM peak hour and 487 vehicles in the weekday PM peak hour. In Year 2040, the combined removal of these ramps would affect about 395 vehicles in the weekday AM peak hour and 610 vehicles in the weekday PM peak hour. As a result, these users would need to reroute to other general purpose lane on- and off-ramps in the area, which was determined to not impact local intersection operations. The removal of these vehicles from the HOV lanes would improve HOV lane operations north of Main Street, thus resulting in slightly better operating conditions for Alternatives 2B and 5B as compared to Alternatives 2A and 5A.

Ramp Alternatives

Ramp Alternatives A and B were studied as part of the I-5 from SR-55 to SR-57 HOV Improvement Project to analyze the effect on the weaving transition in the southbound direction on the I-5 Freeway from the First Street on-ramp to the SR-55 off-ramp. Both

alternatives would improve the weave density with Ramp Alternative A performing slightly better (a reduction in V/C of about 0.01) due to the longer weaving distance available with this alternative. However, the magnitude of improvements is limited due to the overall over-capacity conditions on the I-5 mainline and within the weave area. Although the decrease in V/C would be relatively minimal during both the weekday AM and PM peak hours, even small increases in capacity can result in improved operations by reducing density and increasing speeds. Both Ramp Alternatives would increase the segment weaving length to meet Caltrans minimum weaving standards with the weave length for Ramp Alternative A proposed to be 2,605 feet and the weave length for Ramp Alternative B is proposed to be 2,295 feet.

Reconfiguring and relocating the First Street southbound on-ramp (and the associated changes to the Fourth Street northbound off-ramp) would cause changes in the local circulation patterns, both on the mainline and surface streets. Therefore, both alternatives would cause a minor diversion of vehicles to SR-55; however, these would not be substantial enough to affect roadway and freeway conditions. In addition to the diversion of vehicles to the SR-55, the local streets circulation patterns would further be disrupted by the redistribution required for the ramp reconfigurations. For example, to accommodate the dual left-turn lanes along eastbound First Street to the new I-5 southbound on-ramp with Ramp Alternative B, the current left-turn movements at the intersection of First Street/Lyon Street would be eliminated and replaced with a new traffic signal at Wright Street (located one block west). As indicated in the intersection level of service analysis under Ramp Alternative A and B, none of the key ramp locations would be impacted due to the rerouting of vehicles due to the closure of the I-5 southbound on-ramp at First Street or any other configuration changes. Evaluation of queuing at ramp locations also identified that adequate storage would be provided to accommodate anticipated queues.